Co-Authorship of scientists in the energy field: a study of the ETDE World Energy Database (ETDEWEB) using Social Network Analysis

by

Vasco Manuel Monteiro

Dissertation submitted in partial fulfilment

of the requirements for the degree of

Master in Information Management

by

Instituto Superior de Estatística e Gestão de Informação

of

Universidade Nova de Lisboa

Co-Authorship of scientists in the energy field: a study of the ETDE World Energy Database (ETDEWEB) using Social Network Analysis

Dissertation Supervised by

Professor Doutor Miguel de Castro Simões Ferreira Neto

and Professora Doutora Ana Maria Brigham Silva Ramalho Correia

November 2011

To my family and friends

“Accept the challenges so that you may feel the exhilaration of victory."

General George S. Patton

Acknowledgements

I would like to thank my supervisors Professor Doutor Miguel de Castro Simões Ferreira Neto as well Professora Doutora Ana Maria Brigham Silva Ramalho Correia for all the support and orientation that made this thesis possible.

I am grateful for Dra Aurora Cardoso's help and for allowing me to use the data without which this study would not have been accomplished.

I wish to thank my family, friends and colleagues for their encouragement, and for being understanding and patient with me, especially during the last three years.

A special thanks to José Diogo Madeira, Ana Martins, Sara Oliveira, Teresa Pereira, Catarina Hall, Ilda Augusto, Thomas Barbour and Alexandre Sousa for all their help and motivation.

And last but not least, I would like to express my deepest and most sincere gratitude to everyone else that, in any manner, helped and encouraged me on this endeavour.

Abstract

This thesis presents a study, using a social network analysis (SNA) approach, to examine the structure of co-authorship collaboration within the research community in Portugal in the energy field, for the period from 1995 to 2010.

The domain of the study is Portuguese scientists, working either in Portugal or abroad; foreign scientists working in Portugal and scientists who have co-authored with either of these groups.

The study uses the most common measures of macro (whole network) and micro (actor-centred) structures of this collaboration.

The data used to design the social network was obtained from the *Energy Technology Data Exchange* (*ETDE)'s Energy Database*, which is the largest collection of energy research and technology literature in the world created under the umbrella of the *International Energy Agency/Organisation for Economic Co-operation and Development (IEA/OECD)*.

The scientific production in the period 1995-2010 is mainly journal articles with 82.6% and the average number of authors in co-authored publications is always higher than 4, with an average of 5.5 authors. Only 8.2% of the resources are single author publications and publications by three authors are the most common type of co-authorship, with 22.7%. Therefore the incidence of co-authorship is extremely high at 91.8%.

The growth of scientific production in the energy field is similar here to the growth of the Portuguese scientific production in the similar field of technology and engineering sciences, for both periods, 2000-2009 and 2004-2009, with 154% and 46% respectively.

Materials Science, Physics of Elementary Particles and Fields and Plasma Physics and Fusion Technology are the three main subjects of scientific publications within this network.

The social network within the energy-field has 12,843 different authors from 1,528 different main organizations, and the following institutions have a prominent influence within the network of the energy field: 7 Institutions of the EURATOM Association, *Instituto Tecnológico e Nuclear*, *Instituto Superior Técnico* of *Universidade Técnica de Lisboa*, Austrian Academy of Sciences, *INETI* (now known as *LNEG*), *Universidade Nova de Lisboa*, *Universidade do Porto*, *Universidade de Coimbra*, *Universidade de Aveiro* and *Universidade do Minho*.

Further research using the database of this study may include using the length of the resource as a variable; studying smaller networks within the energy-field, of a specific subject or keyword or of an institution; and finally a study considering only the country as affiliation and analysing the dynamics of co-authorship between Portugal and the other countries within the energy field.

Keywords: Co-authorship, Collaboration, *ETDEWEB*, Social Network Analysis, *SNA*, Energy, Portugal, R&D

Table of Contents

List of Tables

List of Figures

Abbreviations

AAS	Austrian Academy of Sciences
DOI	Digital Object Identifier
IEA	International Energy Agency
EIP	Enterprise Information Portal
ETDE	Energy Technology Data Exchange
EURATOM	European Atomic Energy Community
INETI	*Instituto Nacional de Engenharia, Tecnologia e Inovação, I. P.*
INIA	*Instituto Nacional de Investigação Agrária*
IST	*Instituto Superior Técnico*
ITN	*Instituto Tecnológico e Nuclear*
LNEG	*Laboratório Nacional de Energia e Geologia*
NCSTRL	Networked Computer Science Technical Reference Library
OECD	Organisation for Economic Co-operation and Development
OSTI	Office of Scientific & Technical Information
R&D	Research and Development
SNA	Social Network Analysis
SPIRES	Stanford Public Information Retrieval System
UAv	*Universidade de Aveiro*
UC	*Universidade de Coimbra*
UMi	*Universidade do Minho*
UNL	*Universidade Nova de Lisboa*
UP	*Universidade do Porto*

UTL	*Universidade Técnica de Lisboa*
VNA	Data format for the *NetDraw* Program

Chapter 1 - Introduction

1.1. – Importance of scientific collaboration and co-authorship

Scientific collaboration in research and publication is very common in the modern era. Li-Chun et al. (2006) provide evidence that cooperation among researchers continues to increase in every scientific field. Hara et al. (2003) highlighted, how in science and technology the effect of this cooperation is significant when addressing complex problems in the contemporary world of “rapidly changing technology, dynamic growth of knowledge and highly specialized areas of expertise”.

Collaboration may be viewed as a process where knowledge flows among scientists, such that individual scientists gain access to new “knowledge capital”. With widening collaboration, scientists gain access to information both directly and indirectly; this in turn affects scientific productivity, both in quality and quantity (Li-Chun et al., 2006).

In turn, Smith (2008) notes that, technological innovation is a critical factor in the long-term economic growth of a country and can only take place successfully within a social environment that provides relevant knowledge and information inputs into the processes of innovation. This is dependent on the efficient transfer and communication of information and knowledge, which is related to the amount and quality of interaction among scientists.

The most formal manifestation of this kind of interaction among scientists is co-authorship, which has increased significantly over the recent decades; in fact during the first half of the twentieth century, scientific papers written by more than one author were relatively rare (Acedo et al., 2006). This increase in scientific publications co-authorship inevitably leads to a scientific output of greater quality or quantity than could be achieved by an individual, as Hudson argues (1996).

Katz et al. (1997) however maintain that co-authorship has been used as a basic counting unit to measure collaboration activity; however this is only a partial indicator of collaboration.

Various difficulties complicate the direct assessment of scientists’ contributions to research, but using the number of co-authors as one method to measure collaboration and to assess relationships between researchers has its advantages, as Subramanyam (2003) highlights: it is invariant, quantifiable, easy and inexpensive to discover. It is also, non-reactive (meaning that the process of determining the extent of collaboration does not have impact on the process of the collaboration itself, as for example methods of observation, interviews or questionnaires do).

1.2. - Motivation

This dissertation aims to explore knowledge management further and, more specifically, to deepen the knowledge of the social network analysis field. An evaluation is provided of a database that was not built for the purpose of studying co-authorship or scientific collaboration.

The dissertation was prompted by the reduced application of co-authorship and/or the social network analysis in Portugal, the lack of application in the energy-field in Portugal (considered to be a prominent sector) and the reduced use of the ETDEWEB as a database to explore this type of scientific collaboration.

Clark (2007) points out that social network analysis is a network mapping diagnostic tool developed to understand actors, the relationships between them in a specific social context, and how the actor's position in a network influences their access to resources.

Regarding the study of co-authorship in Portugal, only Donato et al. (2006, 2009) and Neto et al. (2008, 2010a, 2010b, 2011a, 2001b) have explored this subject in the context of Portuguese scientific production and collaboration.

Donato et al. (2006, 2009) have used quantitative and qualitative bibliometric indicators to evaluate scientific production.

In Donato et al. (2006), a study was made on the Portuguese scientific production in the field of breast pathology from 1995 to July 2005 using 3 databases – *Medline*, *Science Citation Index* and the *Index of the Portuguese Medical Journals*. The purpose of the study was to provide an overview of the developed scientific activity being carried out on this subject, enabling the characterisation of its relevant features and its evolution over the period in question.

In 2009, Donato et al. (2009) an evaluation was undertaken of the scientific production of Portuguese institutions in the oncology domain covering a 10 year period (1997-2006), using the *Web of Science*, the *Science Citation Index* and the *ISI Thomson Scientific Journal*

Citation Reports, to assess and quantify authors, departments, institutions and scientific investigations relevance in this field.

These above authors pointed out that a) co-authorship is the rule concerning the production of articles; b) Portugal is no exception on these matters and c) articles produced with international collaboration obtained the highest citation rate.

Donato et al. (2009) also concluded that bibliometric analysis was a reliable tool to evaluate the development and quality of scientific production. In parallel, they also concluded that Portuguese scientists gained more awareness among their peers because there was an increase in the number of articles published by them in international journals of recognized reputation.

Neto et al. (2008) have explored knowledge creation and transfer in the Portuguese agricultural R&D field, using social network analysis. This exploratory study used data from an information system containing the results from the scientific activities developed by the research community working in *INIA*. From this data, using social network analysis, a knowledge network was drawn based on co-authorship patterns extracted from the information system, covering the period of 2000-2006.

Neto et al. (2010a, 2010b, 2011) and Ferreira et al. (2011) have investigated knowledge management and human capital assets, using social network analysis. This study used data from an Enterprise Information Portal of the *Instituto de Telecomunicações*, a Portuguese private non-profit organization which is a partnership of six Portuguese institutions with experience in R&D in the telecommunications field.

Regarding the use of the ETDEWEB database, Hassan (2005) has used the data on scientific publications from the *ETDEs* Energy database, cross-referenced with another database, the *Science Citation Index Expanded*, in order to evaluate the evolution of the knowledge structure of fuel cells, one specific subject within the energy field, in a bibliometric approach. This article includes results from a wider *OECD* Research Project on energy technology, which was published by the *OECD* (2005) entitled "Innovation in fuel cells: a bibliometric analysis."

Cuttler (2004) has conducted a study in which explores the existing grey literature in energy; although this author considered ETDEWEB as one of the initiatives on the list of international partnerships, the fact is that this database does not include grey literature. Grey literature is a set of works, such as internal company documents, doctoral dissertations, master's theses, and conference proceedings not usually available through regular market channels.

Cuttler (2010) compared the ETDEWEB with generic (i.e. non-energy field) search engines *Google* and *Google Scholar* (the *Google* offshoot that provides information about scholarly literature). The primary objective was to verify that ETDEWEB could supply results that were not identified by *Google* and *Google Scholar,* and these results provide unique results not shown by *Google* and *Google Scholar* 86.7% of the time.

Taking all these considerations into account, we concluded that it would be relevant to carry out the study with the objectives outlined in chapter 1.3.

1.3. - Objectives

This thesis utilises the social network analysis approach to examine the structure of co-authorship collaboration in the energy field by Portuguese scientists working either in Portugal or abroad, by foreign scientists working in Portugal or by scientists who have co-authored with either of these groups, in the period of 1995 to 2010. It uses the most common measures of macro (whole network) and micro (actor centred) structures of this collaboration (Li-Chun, Y et al., 2006).

The data used to build the social network was obtained from the *Energy Technology Data Exchange (ETDE)'s Energy Database (*ETDEWEB*)*. By December 2010, there were over 9,700 records of publications involving scientists and research institutions, covering the above-mentioned criteria. Based on the knowledge network drawn using social network analysis, we can analyse specific paths through which knowledge sharing occurred within the energy field in Portugal.

This thesis addresses three main research areas:

- Has co-authorship evolved in the energy field in Portugal and how?
- How is scientific productivity in the energy field in Portugal?
- What social structure can be identified concerning collaboration in the energy field in Portugal? Are there any dominant researchers/institutions?

In order to answer the main research areas, this thesis is structured as follows:

- A literature review (chapter 2) of scientific production and productivity evolving of co-authorship, using either a traditional approach, bibliometrics, to access scientific collaboration in co-authorship or of social network analysis as a complementary methodology;

- The presentation of the ETDEWEB database (chapter 3) and the research approach to its data (chapter 4);

- An analysis of the co-authored scientific publications (chapter 5), followed by a social network analysis (chapter 6);

- Presentation of the main conclusions, limitations of the study and suggestions for future research work (chapter 7).

Chapter 2 – Literature Review

2.1. – Scientific Collaboration and Productivity

Scientific collaboration is a complex social phenomenon in research that has been systematically studied since the 1960s (Glänzel and Scubert, 2004).

The complexity starts with its own definition (Katz & Martin, 1997). At a first level, scientific collaboration can be defined as researchers working together to achieve a common goal of producing new scientific knowledge, but this raises the question of where a less formal connection between scientists ends and collaboration begins. For Katz & Martin (1997), at the one end a collaborator could be anyone who provides an input to a particular piece of research and, at the other end; collaborators are only those scientists who contributed directly to all the main research tasks throughout the entire project. Considering both definitions weak, the authors conclude that the definition of collaboration lies somewhere between the two points.

Hence, they established, despite the exceptions that could be identified in some particular fields, institutions or countries, some criteria that defined collaborators among the other researchers:

a) Who work together on the research project throughout its duration or for a long period, or who make frequent or substantial contributions;

b) Whose names or posts appear in the original research proposal;

c) Responsible for one or more of the main elements of the research.

For the authors, in some cases this could also include the researchers responsible for a key step and who originally proposed the project and/or a fundraiser, even if subsequently the main contribution is for managing the research rather than doing the research per se. On the other hand, this should exclude the researcher who only contributes occasionally or gives a small contribution to part of the research, as well as those people not seen as proper researchers such as technicians or research assistants, which means that the authors refer the location of the collaboration boundary as varying across institutions, fields, sectors, and over time.

Despite the complexity, the fact is that scientific research has become more collaborative over the years. As Subramanyam (1983) stated, scientists are working less in isolation; they are members of a world-wide community that works together.

In this world-wide community, this author identified, depending on the participants, six types of collaboration:

1) Teacher-student collaboration, common in an academic field;
2) Collaboration among colleagues, common in corporate research centres for a number of colleagues working on one or several projects;
3) Supervisor-assistant collaboration, common in research projects where the principal researcher is assisted by technicians;
4) Researcher-consultant collaboration common in large-scale research projects where the main researchers have the assistance of a consultant for specialized tasks;
5) Collaboration between organizations, when scientists and engineers of different organizations often collaborate on research projects of mutual interest;
6) International collaboration, as studied by Frame & Carpenter (1979) who found that the extent of international collaboration was inversely proportional to the size of a country's scientific enterprise and that the extra-scientific factors such as geography, politics and language, played a strong role in determining who collaborates with whom in the international scientific community.

The nature of scientists' contributions in scientific collaboration can be divided into two major groups, technical contribution and theoretical contribution, as Hefner (1981) pointed out. The first takes place when the collaboration applies to tangible activities in the research (*e.g.*, : collecting and processing data, operating laboratory equipment, performing statistical analyses, etc.), and the second is when the collaboration is more intangible, like rendering advice, ideas or criticism or even giving assistance such as reading, editing and/or commenting an article.

The involvement, the nature and the degree of scientific collaboration depends on the field being studied. As Subramanyam (1983) highlighted, scientific collaboration varies from one field to another and depends on demographic factors, nature of the research problem and on the research domain, *i.e*. tends to be lower in the humanities fields and higher in intensely collaborative scientific and technical fields.

Although Katz and Martin (1997) corroborate the idea of Gländel and Scubert (2004), quoted above, that there are various studies regarding research and scientific collaboration, they consider that there is a lack of analysis of the concept of collaboration or of the adequacy of using co-authorship indicator as a measure to assess this.

Katz and Martin (1997) took this further and recognised that within the community there were implicit fundamental assumptions regarding what was scientific collaboration that were never validated, and they showed that collaboration is a far more complex concept which can take many forms. These implicit assumptions referred to by Katz and Martin (1997) were:

- Collaboration is “a good thing” and therefore must be encouraged;
- Analysis of collaboration between individuals, groups, institutions, sector or even countries is the same phenomenon;
- We can in some way measure the level of collaboration and determine if a particular policy impacts or not on collaboration;
- More collaboration is positive for the advancement of knowledge.

Katz and Martin (1997) also highlight that research on collaboration is based in 4 major categories. The first one is the measurement of the research collaboration itself; the second, the factors that encourage the creation of research collaborations; the third, the sources of collaboration, that normally is more centred on the propensity to collaborate and share ideas, with focus on communication and social and physical proximity issues; and last, the effects of scientific collaboration on scientific productivity and on the impact of joint research.

Although the three latter categories referred above are very important to understand the dynamics and knowledge transfers within the scientific networks themselves, our study is more centred in measuring research collaboration, using co-authorship as an indicator for assessing scientific collaboration and productivity.

This literature review will focus mainly on the first category because it is the type that is at stake in the current study; nevertheless an overview of the other three categories will be presented to contextualise the scientific collaboration issue.

As referred to by Acedo et. al (2006), co-authorship is the most formal manifestation of intellectual collaboration in scientific research. It involves the participation of two or more authors in the production of a study and, as Hudson (1996) also highlighted, leads to a scientific output of greater quality or quantity than could be achieved by an individual. Nudelman and Landers (1972) early concluded that the total credit given by the scientific community to all the members of a co-authorship publication is greater on average than the credit allocated to the author of a single-author publication.

For Katz and Martin (1997) these co-authors' (or multiple-authors) publications have been used as a basic counting unit to assess the collaborative activity within research teams, despite the limitations such measure has for the authors. This method of analysing scientific collaboration is only a partial indicator, because at first it can only be used to account for the collaborations where the authors have put their name in the joint paper and, secondly, because there are authors that share the credit in a scientific publication, but are not responsible for the work.

Katz and Martin (1997) explained that it is necessary to distinguish collaboration and co-authorship, since the two are not synonyms. In order to make clear the differences, they presented two scenarios:

- Two researchers can work together closely, but decide to publish their results separately, either because they are from different fields and each one decides to produce a single-author paper for his/her disciplinary audition or because they might disagree in the interpretation of the research and decide to present each of their views separately;
- Researchers that never worked together in their research but decide to pool their findings and write a multi-author publication together.

These two examples show that "*collaboration is not all time 'consummated' in the form of a joint article*". Therefore, they concluded that co-authorship can be used as an indicator of research collaboration between individuals, although being an imperfect or partial indicator.

Regarding the second category proposed by Katz and Martin (1997), they concluded that there is a wide range of factors that contribute to collaborative activity, but few specific reasons have been clearly established to explain how and why it occurs.

Several other authors proposed various factors to explain the increase of co-authorship. The most relevant are outlined in the following paragraphs.

Beaver and Rosen (1978, 1979a, 1979b) have identified 18 motives for collaboration and co-authorship - access to special equipment of facilities, access to special skills, access to unique materials, access to visibility, access to recognition, efficiency in use of time, efficiency in use of labour, to gain experience, to train researchers, to sponsor a *protégé*, to increase productivity, to multiply proficiencies, to avoid competition, to surmount intellectual isolation, need for additional confirmation of evaluation of a problem, need for stimulation of cross-fertilization, spatial propinquity, and accident or serendipity.

Heffner (1981) analysed the changing patterns or levels of funding, and concluded that financial support for research in various fields was associated with the increase in the total number of persons involved in the production of knowledge per research paper.

Katz and Martin (1997) proposed several reasons why the level of research collaboration has been growing over time: the escalating instrumentation costs for conducting fundamental science at the research frontier, the substantial fall in the cost of travel and communication, the growing importance of networking and interaction, the complexity of the instrumentation, the interdisciplinary character of research, and the political factors encouraging collaboration.

About the sources of collaboration, the third category proposed by Katz and Martin (1997), they concluded that informal communication may lead to increasing commitment to collaborate or co-operate and that the spatial proximity seems to encourage this type of communication. They point out that collaboration exists more often between peers than between individuals with unequal rank or status.

Finally regarding the effects of collaboration on productivity, the last category proposed by Katz and Martin (1997), several authors, Beaver and Rosen (1979), Pao (1980, 1981) concluded that high productivity in terms of published output is correlated with high levels of collaboration.

Katz and Martin (1997) also concluded that the most active authors, those with greater outputs in scientific publications are the ones that collaborate the most. They also concluded that normally authors in all levels of productivity tend to collaborate with highly productive authors rather than with lower-productivity authors.

As Melin and Persson (1996) concluded there are various forms of collaboration in research, as well as reasons for collaboration that a co-authorship study is not able to reveal. They have proposed a visual concept about co-authorship and collaboration, presented in figure 1, the dotted lines and squares needing other sources of information to be analyzed.

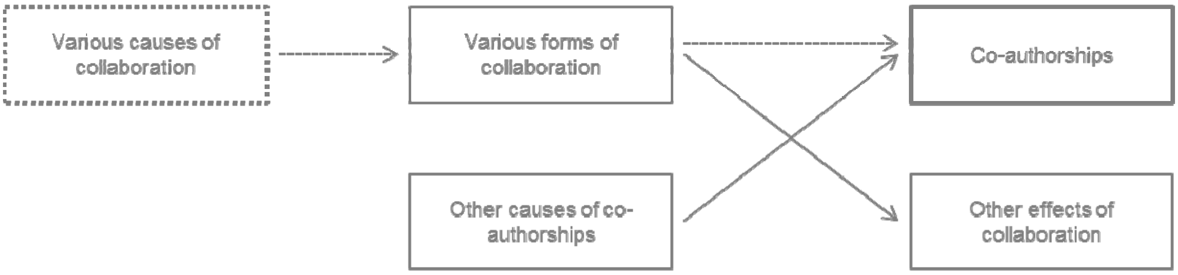


Figure 1 : Co-authorships and their causes

2.2. – Informetrics as a methodology

In order to study scientific collaboration and productivity and co-authorship as an indicator we have to understand the informetrics involved, because it includes a broader set of methodologies that help to study this issue.

At the beginning of the 21st century, there was a considerable growth in webometrics, mapping and visualization of data and in the open access to scientific literature. This renewed interest in indicators of scientific collaboration was conducive to the fact that traditional topics like citation analysis and informetric theory are also continuously developing (Bar-Ilan, 2008).

Tague-Sutcliffe's (1992) define informetrics as follows:

> "Informetrics is the study of the quantitative aspects of information in any form, not just records or bibliographies, and on any social group, not just scientists".

And Egghe (2005) states that

> "It comprises all the metrics studies related to information sciences, including bibliometrics (bibliographies, libraries ...), scientometrics (science policy, citation analysis, research evaluation ...) and webometrics (metrics of the web, the Internet or other social networks such as citation or collaboration networks)".

According to Bar-Ilan (2008), informetrics comprises several areas of study, namely:

- Methods and techniques (mapping and visualization, text and data mining and other linguistic techniques, network analysis, classification);
- Citation analysis (characterizing publication and fields based on citation analysis, co-citation analysis, self-citation, ego-centred citation, quality assessment);
- Indicators (h-index, impact factor); webometrics (web impact factors, academic web, commercial sites, linking motivations and content analysis with qualitative studies, journal impact factors, web visibility and citations);
- Journals (journal quality, journal coverage and structure, journal profiles);
- Open access and electronic publications; productivity and publications (country level studies, field specific studies, interdisciplinary);
- Collaborations;
- Research policy (research evaluation, university rankings);
- Patent analysis (patent citations and other patent indicators).

Originally, bibliometrics was limited to collecting data on numbers of scientific articles and other publications, classified by author and/or by institution, field of science, country, etc., in order to construct simple “productivity” indicators for academic research. Subsequently, more sophisticated and multidimensional techniques based on citations in articles (and more recently also in patents) were developed. The resulting citation indexes and co-citation analyses are used both to obtain more sensitive measures of research quality and to trace the development of fields of science and of networks (Frascati Manual 2002).

Its analysis uses data on number of authors of scientific publications and on articles and the citations therein (as well as the citations in patents), to measure the “output” of individuals/research teams, institutions and countries, to identify national and international networks, and to map the development of new (multidisciplinary) fields of science and technology, for making decisions regarding funds for R&D activities and to delineate scientific policies on R&D.

Another methodology and technique within the informetrics field is network analysis. As Bar-Ilan (2008) refers, network analysis is a huge topic which includes complex networks and social network analysis.

And according to Scott (2000), social network analysis is an interdisciplinary methodology developed mainly by researchers in social psychology during the decades of 1960 and 1970, and was further developed in collaboration with mathematics, statistics and computing which led to a rapid development of analyzing techniques and began to be used as an attractive tool for other fields such as economics, marketing and industrial engineering. He remarks that this is based on the importance of relationships among interacting nodes, and these relations defined by links among nodes are a fundamental component of this methodology.

Clark (2007), on the other hand, pointed out that social network analysis is a network mapping diagnostic tool developed to understand actors, the relationships between them in a specific social context, and how the actor's position in a network influences their access to resources.

With the advancement of computers display capabilities, there has been a growing interest in data mapping and visualization, as Bar-Ilan (2008) pointed out, and therefore the development of software to do it has increased.

Huysman et al. (2003) gives us a state-of-the-art overview of available free and commercial software for social network analysis. They highlight that some of these programs were originally developed for network visualization and now contain analysis procedures, like *Netdraw* (Borgatti, 2002); and other programs were specifically developed to integrate network analysis and visualization, like the *NetMiner* (Cyram, 2003) and the Visone (Wagner, 2003).

Krackplot (Krackhardt, Blythe and McGrath, 1994) and *Mage* (Richardson, 2001) are two other software for social network analysis which Huysman et al. (2003) consider worth mentioning along with the other previously quoted; they either have export functions for these graph drawing programs, or they are freely distributed together with the social analysis software

Appendix A of this study contains an overview of selected programs for social network analysis, reviewed by Huysman et al. (2003), including the version number that was reviewed, their objectives, data format (type, input format, missing values), functionalities (visualization techniques, analysis methods), and support (availability of the program, manual and online help).

On the one hand, the development of technology, the open and free access to scientific literature increases the citation to publications (Lawrence, 2001) and on the other hand, gives access to databases and data, which can be material to studies related with co-authorship.

2.3. – Co-authorship and Social Network Analysis

Although collaboration can be modelled in terms of co-authorship, we can use other methodologies such as analyzing social ties, co-citations and inter citations. White, Wellman and Nazer (2004) study collaboration patterns using this last methodology in the Globenet, an international and interdisciplinary group of researchers studying human development.

As Cronin et al. (2003) and Moody (2004) note, in almost all scientific subjects there is a growing tendency for co-authorship; this is reflected in the articles appearing in journals.

For a better analysis of this trend and its understanding, it is necessary to distinguish between the incidence of co-authorship and the extent of co-authorship (Laband and Tolisson, 2000). The first one refers to the proportion of articles of multiple authors, and the second to the average number of authors of co-authored articles. The same authors (op. cit) highlighted that, for example, both - the incidence and extent of co-authorship - are greater in the natural sciences than in the social sciences.

For Hara et al. (2003), in science and technology the effect of cooperation is significant when addressing the complex problems that should be addressed by scientists in the contemporary world of "rapidly changing technology, dynamic growth of knowledge and highly specialized areas of expertise". Thus, it is important to see which factors determine the increase of this kind of cooperation. Acedo et al. (2006) consider that both factors are general, those affecting all scientific fields, and specifically, those affecting particular scientific fields.

In the first group of factors – those affecting scientific fields -, McDowell and Melvin (1983) refer to the increasing specialization within science and point out that the growing number of scientists in all disciplines increases the likelihood of finding the necessary collaborators for research. In addition, Barnett et al. (1998) refer to the process of division of labour as an important factor, which was motivated by the continual expansion of the stock of knowledge. It is important to note that the improved methods of communication among geographically separated scientists also facilitate co-authored papers (Katz and Martin, 1997; Laband and Tollison, 2000).

The second group of factors – those affecting specific fields - includes the increasingly technical nature of disciplines (Hudson, 1996; Katz and Martin, 1997) and specializations within disciplines (Laband and Tollison, 2000). Hudson (1996) referred that interdisciplinary research requires the interaction of specialists from various fields, and thus tends to produce collaborative research.

Laband and Tollison (2000) pointed out that in the natural sciences the sharing use of laboratories and expensive equipment by research teams are also contributing towards a greater extent of co-authorship.

Moody (2004) noted that despite what is referred above regarding co-authorship being predominantly a phenomenon occurring at natural sciences and science and technology, in social sciences research teams are becoming more and more common. However, there is evidence of some reluctance to publish papers in this field with a large number of authors (Acedo et al., 2006). In line with this, Nathan et al (1998) noted that a study authored by more than four authors per article, was considered to be too many, in the domain of the social sciences.

As Cronin (1996) indicates, although the study of co-authorship relationships is only one of the possibilities for measuring formal and informal collaborations of scientists, it assumes particular relevance because it is fundamental in leveraging scientific activity. In many cases, the status, salaries and reward systems of scientists are linked to the quantity and quality of the articles that they publish.

This measure of co-authorship assumes an important contemporary role, because of the institutional pressure on researchers to increase their productivity by publishing scientific work and the fierce competition for the finite space available in scientific journals. “Publish or perish” dictates success or failure in the competition for funds and other resources (Piette and Ross, 1992).

Beaver (2004) highlighted that multi-authored papers have greater epistemic authority than singled authored papers, based on a study of 33 researchers at Williams College, *i.e.*, co-authorship tends to be more accepted among the scientific community.

However, there is a debate around the quality of those co-authored publications and their acceptance in journals. Barnett et al. (1998) formulated a “quality hypothesis” where they attempted to identify the quality or impact of co-authorship in terms of the complexity of the subjects involved, and whether they required a combination of skills of multiple researchers.

Laband and Tollison (2000) have demonstrated that co-authoring improves the quality of work and improves the probability of acceptance. Although quality is a very important variable for paper acceptance, it is not the only criterion. As Laband (1995) pointed out, acceptance also depends on affiliations among the authors, editors, and co-editors of the journals to which the papers are submitted.

In networks of research communities, information and intellectual capital are among the most important resources; their flows and bottlenecks, within the communities, can be studied by social network analysis, according to Neto et al. (2008).

Katz and Martin (1997) highlighted that not only do these relationships facilitate the communication with colleagues of colleagues, but also the sharing of strategic information within a network. Therefore, the study of these networks allows us to understand some of the characteristics of a particular subject and to identify the invisible colleges and social groups that exist in all scientific fields (Acedo et al., 2006).

Borgatti and Foster (2003) have shown that the exponential growth of scientific literature regarding social network analysis is part of the shift that occurred during the second half of the 20th century to a more relational, contextual and systemic understanding; pulling away from the individualist, essentialist and atomistic explanations that were evident before.

The use of social network analysis as a methodology is finding increasing applications outside the social sciences and up until now has been applied to areas as diverse as business organizations, electronic communication, health and psychology, sustains Clark (2007).

According to Acedo et al. (2006), a more recent and complementary approach to the study of co-authorship of scientific publications focuses on the relationships among the co-authors. This approach to assess scientific collaboration is based on the assumption that co-authorship creates a social network of researchers that develops over time, concluded Hara et al. (2003). If one maps the network of co-authorship using SNA, it is possible to infer the structure of the collaboration that is taking place between network members.

As Acedo et al. (2006) pointed out, the social and academic links created through co-authorship are both direct and indirect; through a third person, researchers gain access to other researchers previously unknown to them.

Several authors highlighted that the potential of the social network methodology is opening up an interesting line of investigation about co-authorship.

Barabási et al. (2002) studied co-authorship networks as complex systems, analyzing co-authorship networks and their evolution over time in the fields of neurosciences and mathematics.

Newman (2001), on the other hand, focuses more on the study of the dynamic aspects of collaboration networks and showed that the probability of collaboration is correlated with the number of mutual acquaintances and their previous collaboration pattern, considering social network analysis of co-authorship networks based on Medline, Physics e-print archive, SPIRES (high energy physics) and NCSTRL (computer sciences).

In theory, these studies should provide a basis for thinking about how a community is organized and what actions might be appropriate to create and develop an environment in which collaboration research is encouraged and ideas shared (Vidgen et al., 2007).

In brief, the application of the social network analysis methodology in the study of co-authorship brings forth two important perspectives (Acedo et al, 2006). The first, is a description of the process by which scientific collaborations come about, including the structural patterns that occur among scientists at the time of publishing the results of their investigation (Newman, 2001) or in the process of these collaborations (Barabási et. al., 2002). The second is an examination of the community of scientists as a social network of individual actors in which each person occupies a distinctive position allowing him or her to benefit from various opportunities. The patterns of these relationships reflect an underlying social structure that affects production processes and the diffusion of knowledge (Piette and Ross, 1992).

Regarding the network dynamics of a network, Watts (2003) highlighted that there are two types of dynamics that can be studied and defined; one, the dynamics of the network, the other, the dynamics on the network. The dynamics of the network refers to the evolving or changing structure of the network itself, the making and breaking of ties, and can be analysed with snapshots taken during this ongoing process of evolution. The dynamics on the network is centred in the actions of the individuals; they can search information, lean, spread rumour, make decisions. Those actions are too influenced by what their neighbours are doing and therefore, to some extent, by the network structure either locally, from the closest individuals, or globally, from those more distant.

Newman (2003) developed estimates of the number of “friend-to-friends” a person has; considering co-authorship, using social network analysis, this measure applies to the number of authors that co-authored papers with the co-authors of the specific authors.

The development of technology, the open and free access to scientific literature increases the citation of publications (Lawrence, 2001). On the other hand, it gives access to databases and data that can be the raw material to studies related with co-authorship and citation analysis.

Chapter 3 - The ETDEWEB database

The *ETDE – Energy Technology Data Exchange*, an international energy information exchange agreement, was formed in 1987 under the *International Energy Agency/Organisation for Economic Co-operation and Development (IEA/OECD)*; the Portuguese Government has designated the former *INETI (Instituto Nacional de Engenharia, Tecnologia e Inovação, I. P.),* today known as *LNEG (Laboratório Nacional de Energia e Geologia*), as the Contracting Party for Portugal. The aim was to provide added visibility to the research work performed in Portugal by the research community within the scope of the *ETDE* ´s database. Although, Portugal is not a full member, since 2010, due to government decisions based on financial constraints, this study concentrates on the period between 1995-2010, during which Portugal contributed to the database as a full member (with the exception of the last year).

An Internet tool – the *ETDEWEB* (https://www.etde.org/etdeweb/) – was developed to disseminate energy research and technology information, collected by 14 *ETDE* Member Countries and international partners (as in November 2011), to all its other members; since 2004, free internet access database has been extended to more than 50 developing countries worldwide.

ETDEWEB is the largest collection of energy research and technology literature in the world with a growing total of over 4,6 million abstracted and indexed records in the full collection, as of November 2011. *ETDE* began the database in 1987 but historical energy-related information from the U.S. Department of Energy's Office of Scientific and Technical Information (*OSTI*) databases is also included, extending coverage back to 1974.

As Cuttler (2010) concluded in a study about the *ETDE* database, for 15 subjects available in the ETDEWEB, the database identifies to the user unique results not shown by the Google search-engine, or by Google Scholar (the search-engine from Google that provides information about scholarly literature) 86.7% of the time.

The same study concluded that the *Google* search-engine is a valuable tool to find significant non-specialized information and *Google Scholar* helps the user focus the search on scientific subjects. But if a user’s interest is scientific and energy-specific, *ETDEWEB* continues to hold a strong position in the energy research, technology and development information field and adds considerable value in knowledge discovery in the energy-field related areas.

Input to the ETDEWEB is a shared endeavour; all 14 participants participate in preparing their one database entries. Each member country is responsible for the input of the relevant publications produced within its frontiers. *ETDE* also has partnerships with other international organizations, which contribute to enrich the database content.

In Portugal, the input was made by *INETI* until 2010; the referees were *INETI´s* Researchers, and the database could be accessed by other Portuguese entities, on completion of a preliminary registration form (https://www.etde.org/etdeweb/register.jsp).

The ETDEWEB users include researchers, policymakers, academics, information specialists, and private citizens requiring answers to energy-related science and technology questions. They can identify in this repository the latest developments, people and countries involved in a particular research area and energy-related environmental and climate change issues, including policy and economic factors, alternative and renewable energy sources and energy conservation.

The database contains bibliographic references and abstracts for journal articles, reports, conference papers, books, websites, and other miscellaneous document types not commercially available. It also provides direct download access to 437,000 full text items via the *ETDE* operating site and via the *OSTI* site, to 1,158,000 DOI links, through which the item can be obtained from the publisher and to many more documents that are stored on organizations' websites around the world (as of November 2011).

The subject areas covered in the database are extensive and are organized in 55 subject categories. Some of the main areas include information on energy R&D; energy policy and planning; basic sciences (*e.g.*, physics, chemistry and biomedical) and materials research; the environmental impact of energy production and use, including climate change; energy conservation; nuclear (*e.g.*, reactors, isotopes, waste management); coal and fossil fuels; renewable energy technologies (*e.g.*, solar, wind, biomass, geothermal and hydro).

Subject categories are used by *ETDE* to classify records. Typically, these fall into four general types:

- Those representing energy sources, *e.g.*, Coal, Lignite and Peat, Solar Energy, Wind Energy, therefore considered main subject 1;
- Those representing energy production, utilization, and management, *e.g.*, fossil-fuelled power plants and energy conservation, consumption and utilization, therefore considered main subject 2;

- Those representing energy conversion and storage, *e.g.*, direct energy conversion and energy storage, therefore considered main subject 3;
- Those containing basic information developed in support of energy production, conversion, and utilization, *e.g.*, chemistry and physics, therefore considered main subject 4.

The list below takes a more in-depth look at the subject categories (category numbers are in parentheses and general type – mentioned above – in square brackets) used for the database and provides a better idea of the breadth of what can be found.

- Coal, Lignite and Peat (01) [1]
- Petroleum (02) [1]
- Natural Gas (03) [1]
- Oil Shales and Tar Sands (04) [1]
- Isotopes and Radiation Sources (07) [1]
- Hydrogen (08) [3]
- Biomass Fuels (09) [1]
- Synthetic Fuels (10) [3]
- Nuclear Fuel Cycle and Fuel Materials (11) [1]
- Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]
- Hydro Energy (13) [1]
- Solar Energy (14) [1]
- Geothermal Energy (15) [1]
- Tidal and Wave Power (16) [1]
- Wind Energy (17) [1]
- Fossil-Fuelled Power Plants (20) [2]
- Specific Nuclear Reactors and Associated Plants (21) [2]
- General Studies of Nuclear Reactors (22) [2]
- Power Transmission and Distribution (24) [2]
- Energy Storage (25) [2]
- Energy Planning, Policy, and Economy (29) [2]
- Direct Energy Conversion (30) [2]
- Energy Conservation, Consumption, and Utilization (32) [2]

- Advanced Propulsion Systems (33) [4]
- Materials Science (36) [4]
- Inorganic, Organic, Physical and Analytical Chemistry (37) [4]
- Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]
- Chemistry (40) [4]
- Engineering (42) [4]
- Particle Accelerators (43) [4]
- Instrumentation (44) [4]
- Military Technology (45) [4]
- Instrumentation Related to Nuclear Science and Technology (46) [4]
- Other Instrumentation (47) [4]
- Environmental Sciences (54) [4]
- Biology and Medicine (55) [4]
- Biology and Medicine (56) [4]
- Geosciences (58) [4]
- Applied Life Sciences (60) [4]
- Radiation Protection and Dosimetry (61) [4]
- Radiology and Nuclear Medicine (62) [4]
- Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63) [4]
- Physics (66) [4]
- Plasma Physics and Fusion Technology (70) [4]
- Classical and Quantum Mechanics, General Physics (71) [4]
- Physics of Elementary Particles and Fields (72) [4]
- Nuclear Physics and Radiation Physics (73) [4]
- Atomic and Molecular Physics (74) [4]
- Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]
- Nanoscience and Nanotechnology (77) [4]
- Astronomy, Cosmology and Astrophysics (79) [4]
- Knowledge Management and Preservation (96) [4]
- Mathematical Methods and Computing (97) [4]
- Nuclear Disarmament, Safeguards and Physical Protection (98) [4]
- General and Miscellaneous (99) [4]

As of November 2011, the following subjects are not listed on the *ETDE site*, although records are found in the *ETDE* database within these subjects, and in the dataset used for this study:

- Chemistry (40) [4]
- Instrumentation (44) [4]
- Military Technology (45) [4]
- Physics (66) [4]

In the period 2004-2008, Physics represented, 27.7% of the new entries in the database, one of the subjects that does not exists in the subject list today. The high percentages presented for physics and materials area, although valid, are a bit higher than normal, because in that period *ETDE* work with publishers in order to cover some older material. In the figure 2 represents the subject coverage for the period above quoted above (*ETDE*, 2011)

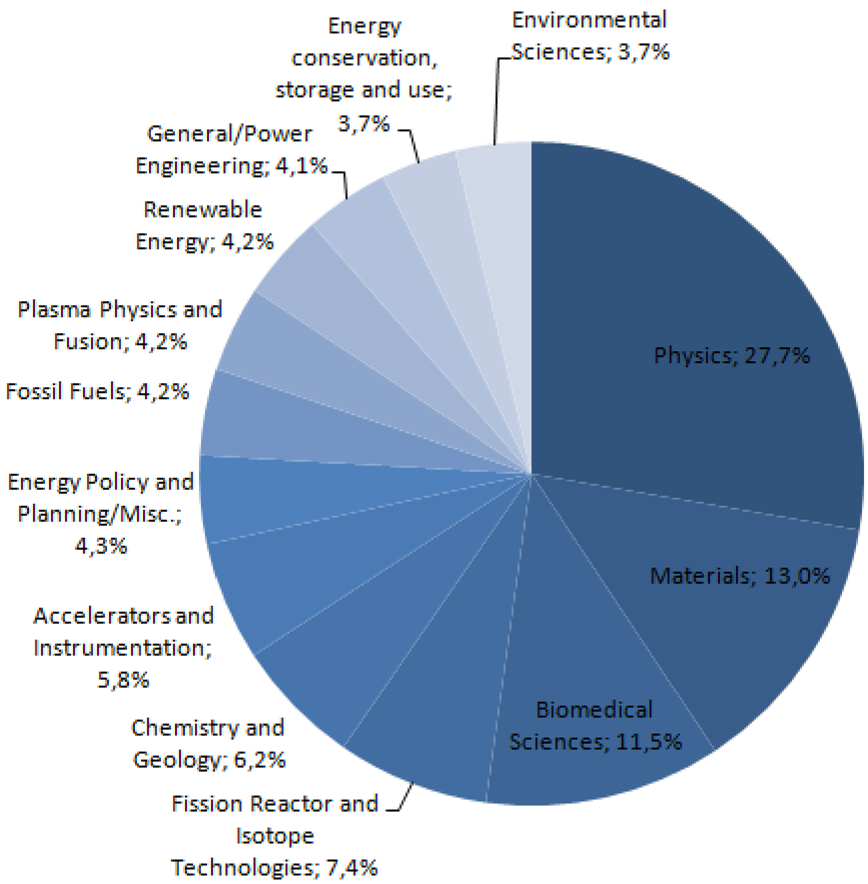


Figure 2: Subject Contents of the ETDE database during the period 2004-2008

Table 1 represents the contribution of each full-member from 2008 to the third quarter of 2011 (*ETDE*, 2011). Presently there are only 14 full-members, as per information on the *ETDE* site as of November 2011, which excludes France and Portugal. As mentioned above, Portugal withdrew from *ETDE* in 2010.

	2008		2009		2010		2011 Q1		2011 Q2		2011 Q3	
	#	%	#	%	#	%	#	%	#	%	#	%
Brazil	4,852	3.9%	5983	5.3%	401	0.4%	1763	7.5%	172	0.5%	994	4.0%
Canada	4,012	3.2%	3898	3.5%	3679	3.5%	764	3.2%	0	0.0%	79	0.3%
Denmark	304	0.2%	380	0.3%	290	0.3%	60	0.3%	71	0.2%	95	0.4%
Finland	543	0.4%	426	0.4%	693	0.6%	44	0.2%	49	0.1%	75	0.3%
France*	3,496	2.8%	4181	3.7%	2244	2.1%	418	1.8%	1531	4.3%	817	3.3%
Germany	13,658	11.0%	15773	14.1%	14957	14.0%	3362	14.2%	3675	10.4%	442	1.8%
Korea, Republic of	375	0.3%	4041	3.6%	3498	3.3%	864	3.7%	1134	3.2%	102	0.4%
Mexico	347	0.3%	206	0.2%	243	0.2%	45	0.2%	155	0.4%	79	0.3%
The Netherlands	29,801	24.0%	20168	18.0%	1972	1.8%	1991	8.4%	5956	16.9%	4795	19.1%
Norway	529	0.4%	732	0.7%	681	0.6%	119	0.5%	133	0.4%	134	0.5%
Portugal*	72	0.1%	79	0.1%	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Spain	458	0.4%	820	0.7%	888	0.8%	54	0.2%	470	1.3%	242	1.0%
Sweden	1,128	0.9%	1009	0.9%	668	0.6%	92	0.4%	160	0.5%	147	0.6%
Switzerland	328	0.3%	527	0.5%	420	0.4%	484	2.0%	36	0.1%	62	0.2%
United Kingdom	19,529	15.7%	20183	18.0%	28245	26.5%	1777	7.5%	9082	25.8%	7105	28.3%
United States	44,923	36.1%	33797	30.1%	47757	44.8%	11778	49.9%	12637	35.8%	9923	39.5%
Total	124,355		112,203		106,636		23,615		35,261		25,091	

* No full members (as of November 2011)

Table 1: Subject Contents of the ETDE database during the period 2004-2008

Since 2010 Portugal has not contributed to the ETDEWEB and between 2008-2009 only represented 0.1% of the new entries in the database, with 72 records in 2008 and 79 in 2009; the biggest contributors to the *ETDE* database are the United States, The Nethelands, and the United Kingdom.

Regarding the database design, each record in the database includes the following fields: title, creator/author, publication date, resource/document type, resource relation, size/format, subject, description/abstract, publisher, country of publication, language, source, availability, *OSTI* identifier, publication date and other identifiers.

Records that describe documents that are in a native, non-English language will almost always include an English title and abstract to facilitate searching and help users determine if a translation is worthwhile.

Although ETDEWEB is a library, it has a few limitations regarding the direct application of informetrics methodologies, the most important limitation being, not having a master table with the authors data; for instance the creator/author field has both author name and affiliations and the field does not have a standard rule for the data entry.

In the following chapter we will explore the data within the sample of the ETDEWEB used for this study, the steps to create the final set for the co-authorship study and examples of the limitations mentioned above.

Chapter 4 - Research Approach and the ETDEWEB data

The database used in this study was the *Energy Technology Data Exchange (ETDE)'s Energy Database (*ETDEWEB*).* By December 2010, there were over 9,700 records of publications, involving Portuguese scientists, working either in Portugal or abroad, foreign scientists working in Portugal or scientists who have co-authored with either of these groups.

In order to construct the database suitable for social network analysis, some filters and some data standardization were made. In the next paragraphs the approach is described.

Figure 3 explains the process to obtain the co-authorship database from the *ETDEWEB* database.

Figure 3: Process to obtain co-authorship database from ETDEWEB database

After the selection of the data and its data extraction from the ETDEWEB, was done activities of data filtering and data redundancy treatment related with authors and institutions to finally have the co-authorship database, with 5 main tables. In the next paragraphs are described the data filtering and data redundancy treatment.

For this study, 1995 to 2010, was the time period considered. Considering this filter, 1,537 records, 15.8% of the original database, were not considered for this study. With this filter, database decreases to 8,226 records.

Since this is a co-authorship study, the Creator field needed to be filled and be different from "None" or Not Available". Most of the records had this field filled, only 12 records of the original database were not considered for this study.

In order to assess the author scientific area, the subject field needed to be filled. Considering this restriction only 2 records were not considered for this study.

For the data set classification, the subject field was used; from this field only the number of the subject field was considered, and not the keywords that also exists in the field. After this classification per subject field was carried out, a broader classification was done considering the four main general types within the energy field proposed by the ETDEWEB, as referred in chapter 5. Accordingly to this classification, a scientific publication was only classified in one category.

As Acedo et al. (2006), we have considered for our study journal articles and as proceedings are especially common in the field of engineering (Glänzel et al., 2005), we decided to analyse also proceedings papers and not only articles in this study.

As Moody (2004) states, the generally lower rate of co-authorship in books may offset some of the errors introduced by their exclusion in this type of analysis. Consequently, books were not considered for this study. For the same reason, technical reports and other miscellaneous items were not considered. In this database books represent 0.45% of the records; technical reports 2.3% and miscellaneous items 0.7%.

In resume, of over 9,700 existing records, we only considered those that were published between 1995 and 2010, where the subject field was completed, the resource type was Conference or Journal Article and where the creator/author was different from "None" or "Not Available". With these constraints, 7,718 records were available for this study, 68.9% of the original database.

As a preliminary step in any SNA, a detailed data analysis of the ETDEWEB data was carried out. For instance, the field "Creator" has both author's name and affiliations; however authors' names are shown in various ways, e.g.: surname, initial of the first name; initial of the first name and surname; name and surname, etc. Similarly affiliations can appear in full or in a variety of abbreviations; also an author can appear with one or two initials or indicate different affiliations in different publications.

Although Melin and Persson (1996) stated that data on co-authored articles can be retrieved from almost any bibliographic database, both Melin and Persson (1996) and Aswani et al. (2006) stated that mining information in no standardize data is quite a complicated and time-consuming task, especially if all the records of a database have to be dealt with.

While Melin and Persson (1996) focused more on issues relating affiliation, Aswani et al. (2006) focused more on authors' names.

Melin and Persson (1996) stated that generally the country part of affiliation is well standardized. In fact, the ETDEWEB database does not have a lot of records with the wrong country, because most of the time the country name is in English. In some cases, the country is written in the native language of the paper.

Melin and Persson (1996) stated that the city information in the affiliation is easily standardized by eliminating the postal codes. They also noted, that at main organization, the main institution may have a larger number of variants, as well the departments in that organization. Table 2 shows 3 variants of *Instituto Superior Tecnico*, a Portuguese institution, as an example.

OSTI ID	**Example of Affiliation**
21349173	CFTP, Departamento de Fisica, Instituto Superior Tecnico, Av. Rovisco Pais, 1, 1049-001 Lisboa (Portugal)
21352044	Centro de Fisica das Interaccoes Fundamentais, and Departmento de Fisica, Instituto Superior Tecnico, Avenida Rovisco Pais, P1049-001 Lisbon (Portugal)
21353195	Instituto Superior Tecnico, UTL, ICEMS, Av. Rovisco Pais, 1049-001 Lisbon (Portugal)

Table 2 : Example of the same institution variations

The standardization of the affiliation is very important when analysing a co-authorship network, because the study can be focused on countries, cities, regions, main organizations, scientists or group of scientists (Melin and Persson, 1996).

In this study case the affiliation was standardized to consider the main organization, as cited more often, but always related to the scientist, author centred and not main organization centred.

Aswani et al. (2006) considered that due to name variations, identical names and spelling mistakes within the bibliographic databases, a disambiguation person name is difficult.

Table 3 and Table 4 show examples of two authors where name has 3 variations and one of the variations is a misspelling. In the second example we have the first name spelled as an initial and as full name.

OSTI ID	Example of Author
21086801	Limao-Vieira, P.
21142109	Limao-Vieira, P
21229145	Limiao-Vieira, P.

Table 3: Example 1 of the same author variations, with mistake

OSTI ID	Example of Author
20651042	Culyurtlu,Ibrahim
20651043	Gulyurtlu,Ibrahim
189105	Gulyurtlu,I.

Table 4: Example 2 of the same author variations, with mistake

An actor/institution dictionary was created to deal with these variations and all records were updated accordingly. The affiliation allocation was based on the main institution of the author; when it was not possible to allocate an institution to an author, the institution field was designated “Other”. All authors’ names and institutions were standardised.

This approach prevents the same author from appearing on several nodes in the network, and from introducing erroneous results.

As Klitkou et al. (2007) highlighted co-authorship analysis could distinguish between different aggregation levels: co-authorship between countries, sectors within a specific R&D system, institutions and authors. In this study we analysed the co-authorship relations between authors, considering his institution as an attribute.

After the creation of the actor/institution dictionary, which was a very complicated and time-consuming task, as pointed out above by Melin and Persson (1996) and Aswani et al. (2006), more than 1,000 records were not considered to this study because some authors had “Portugal” in their name, and others were authors who had participate in conferences in Portugal, but were not Portuguese scientists or scientists who had a co-authorship relation with Portuguese scientists or institutions. The final dataset for this study is made up of 6,662 records.

Afterwards, this database was split into five different tables, in order to do queries to create the VNA file:

- Articles: table with the publication id, the specific and main subject of the publication, date, the resource type and the number of authors. This database has 6,662 records;
- Authors: table with the author identification, the author's name, the main subject that he normally publishes and all the published categories. This database has 12,843 records. In order to create the main subject and category fields, it was necessary to do some queries, because the subjects were primarily allocated to the articles;
- Institutions: table with the institution identification, the institution name and the country. This database has 1,528 records;
- Articles/Authors (table that connects the table Articles and the table Authors): table with the publication identification, the author identification, and the author order in the publication. This database has 34,165 records;
- Authors/Institutions (table that connects the table Authors and the table Institutions): table with the author identification and the institution identification. This database has 12,857 records.

After creating the 5 tables, and in order to create the node and ties information, was necessary to create 5 main queries.

For the node information in the VNA file, the queries number of publication per author and the node information were used:

- Articles per year: query made with the Articles table, with a restriction on the year of the publication, which returns all the articles publish, for a specific year or in an interval of years. In order to have the information cumulative per year, were made 16 queries, that represents the cumulative articles since 1995 to 2010;
- Number of publications per author: query made using the table articles per author and the query articles per year, which returns the number of publications per author in a

specific year or in an interval. In order to have the cumulative information per year 16 queries were made as in the previous query.

- Node Information: query made using the table authors, authors/institutions and the query number of publication per author, which returns the author identification, author name, main subject of the author, subjects of the author, institution identification and the number of publications, in a specific year or interval of years. In order to have the cumulative information per year 16 queries were made as in the previous query. This query is the information used in the node data of the VNA file.

For the ties information in the VNA file, were used the queries articles per year (already explained above), number of authors and the general query:

- Number of Authors: query made using the Articles/Authors table and the query Articles per year, which returns the number of authors per article, for a specific year or interval of years. In order to have the cumulative information per year 16 queries were made as in the previous query.

- General query: query made using the Articles/Authors table and the query number of authors, which returns the publication identification and the author identification, for a specific year or interval of years. This query was the query used to create the ties data, with an ASP file that generates the information of the connections between the authors. This ASP file only created the connections for the first 20 authors in an article, which means that not all authors connections are represented on the network introduced in chapter 6. Although were not considered in the network, the percentage of articles with more than 20 authors represents only 1.2%, as in the table 10 of the chapter 5. In order to have the cumulative information per year 16 queries were made as in the previous query.

After creating the node and ties information 16 cumulative data, for the specific year was created, and introduced in the *NetDraw* application in order to create the maps presented in the chapter 6.

The ETDEWEB database was not prepared for an immediate utilization for a social network analysis, because the creator/author was not standardized, mainly because they are not specific rules for data introduction of the author and institution in this field. Most of the time this study was preparing the database to be eligible to do the necessary treatments in order to create the final database, with the tables Articles, Authors, Institutions, Articles/Authors and Authors/Institutions in order to create de node and the tie data, for the VNA file used in the *Netdraw*.

Chapter 5 – Analysis of the Co-Authored Scientific Publications

In this chapter we introduced a basic descriptive analysis for the study data. For more information related to this statistical analysis, using the bibliometric approach, see Appendix B.

Tables 5 to 9 includes the analysis of scientific production and tables 10 to 12 will analyze authors' data.

As indicated in Table 5, 6,662 publications have been identified in the main set: 1,162 conference proceedings and 5,500 journal articles indexed in the ETDEWEB database. As pointed out by Glänzel et al. (2005) proceedings are relevant in the engineering field and in this study they represent 17.4% of the data set.

Table: Scientific Production per resource type	#	%
Conference	1162	17.4%
Journal Articles	5500	82.6%
Total	**6662**	**100.0%**

Table 5: Scientific production per resource type (1995-2010)

In an exploratory study, Monteiro et al. (2009) conference proceedings demonstrated greater representativeness than in the actual data set. Previously, conference proceedings represented 26.3% and now only 17.4%, almost 10% less. The previously data set was a subset of the actual study for the period 1995-2008.

Table 6 illustrates the distribution of scientific literature production since 1995. The period 2006-2009 displays the greatest scientific production, with more than 700 records per year, and represents 45% of all scientific production during the years 1995-2010. The relatively low figure for 2010 reflects that data entry of 2010 journal articles or conference proceeding will not be completed until 2011.

Table: Scientific Production per year	#	%
1995	243	3.6%
1996	248	3.7%
1997	219	3.3%
1998	184	2.8%
1999	217	3.3%
2000	281	4.2%
2001	246	3.7%
2002	306	4.6%
2003	371	5.6%
2004	491	7.4%
2005	615	9.2%
2006	734	11.0%
2007	762	11.4%
2008	786	11.8%
2009	715	10.7%
2010	244	3.7%
Total	**6662**	**100.0%**

Table 6: Total scientific production per year (1995-2010)

Throughout the period 1995-2010, only the year 1998 rates below 200 publications, thus being the year with the least scientific production, whereas 2008 was the year with the highest scientific output yielding almost 800 publications.

Figures 4 shows a comparison between the results of this study and the growth rate of the Portuguese scientific production between 2000-2009 and 2004-2009 in various fields, according to *GPEARI* (2010) in the statistical series report 1990-2009 combined with the results of this study.

Although the report from *GPEARI* (2011) regarding 1990-2010, was already available it was not used to compare the growth rate because in this study the year 2010 is not complete (as noted above).

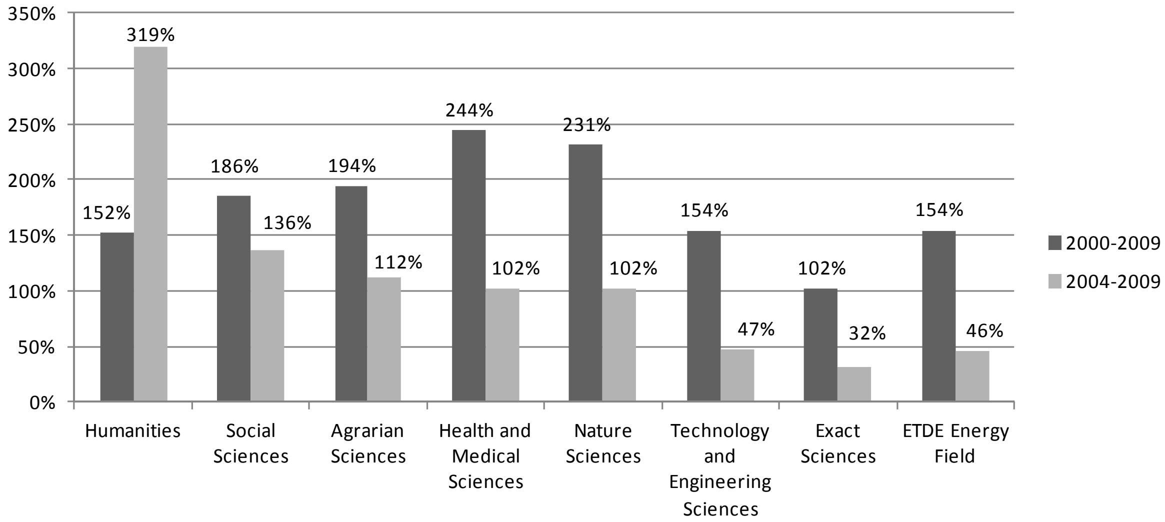


Figure 4: Scientific production growth rate for 2000-2009 and 2004-2009 in various scientific fields

In conclusion, in this study the growth of scientific production in the energy field is similar to the growth of the Portuguese scientific production in the similar field of technology and engineering sciences, in both periods 2000-2009 and 2004-2009. In this study, the growth in the period 2000-2009 is 154% and in the period 2004-2009 is 46%, 1% less than the Portuguese scientific production in technology and engineering field.

Figure 5 highlights the distribution of the resource type over the years. The period 1995-2010 saw a higher scientific production of journal articles than conference proceedings. The difference between conference proceedings and journal articles is very high (at more than 200 scientific publications) for 2002-2010, whereas in the years 1995 and 1999-2001, a smaller difference of less than 70 scientific publications is observed.

2005 is the year with the highest scientific production in conferences, with 123 proceedings published, while 2008, with 708 published journal articles, is the year with the highest scientific production in journal articles.

Excluding 2010, 1998 is the year with the lowest scientific production in conferences, having 30 proceedings published, while 1999 is the year with the lowest in journal articles with 140 published journal articles.

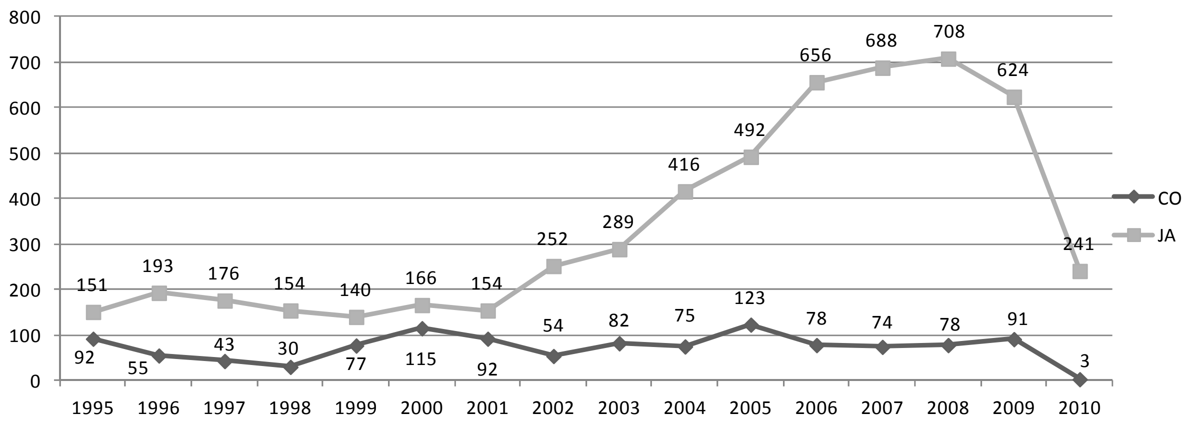


Figure 5: Scientific production for 1995-2010 (Conference (CO) = 1,162; Journal Articles (JA) = 5,500)

Figure 6 shows the comparison of the trends between this study and the Portuguese scientific production, for the technology and engineering sciences field, as stated in the *GPEARI* (2010) report, for the period 1995-2009.

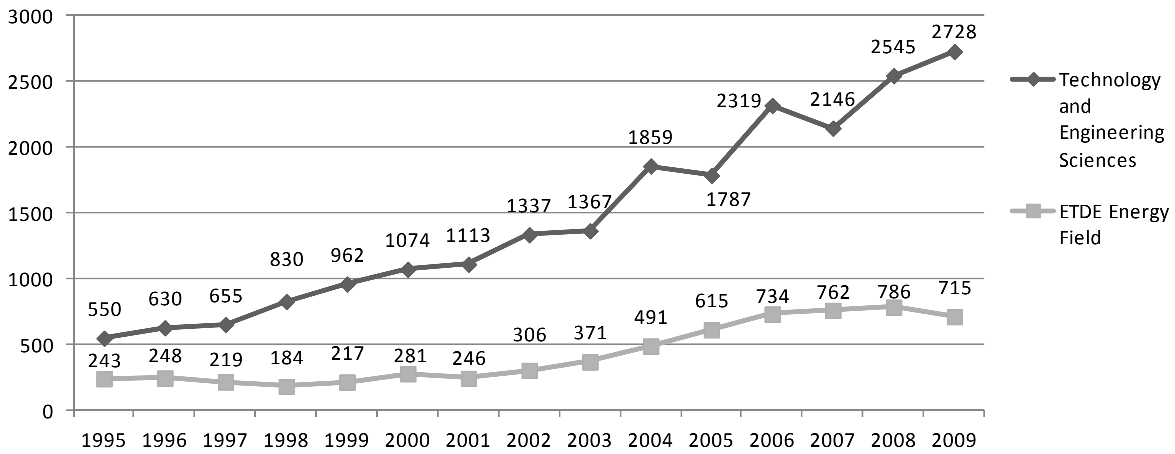


Figure 6: Scientific production for 1995-2009 comparing this study's data with the Technology and Engineering Sciences data from GPEARI (2010)

The evolution is not similar in both scientific fields; Portuguese scientific production in the technology and engineering sciences showed a growth trend since 1995, although with a decrease in production during 2005 and 2007, whereas in the energy field there was a reduction trend in the period between 1996-1998, and again in 2001 and in 2009. However, between 2001-2008 the Portuguese scientific production in the energy field shows a growing trend, in contrast with the overall Portuguese scientific production in the technology and engineering field.

Based on the data of *ETDEWEB*, the shares of the four main categories of publications were calculated, as shown in Table 7. The "Basic information developed in support of the energy field" represents almost 85% of the database, followed by 7.7% of research into "energy sources", "energy production, utilization and management" representing 5.9% of the database and finally research on "energy conversion and storage", which only represents 1.7% of total research.

Table: Main Subjects Distribution	#	%
Energy Sources	514	7.7%
Energy Production, Utilization, and Management	392	5.9%
Energy Conversion and Storage	115	1.7%
Basic information developed in support of energy	5641	84.7%
Total	**6662**	**100.0%**

Table 7: Total scientific production per main subject (1995-2010)

In Table 8 and Table 9, the distribution of the subjects is analyzed, taking into account the 55 subjects categories proposed by *ETDEWEB*.

In 61.2% of the subject categories, equivalent to 30 categories, each category represents less than 1% of the scientific publication, and the sum of all 30 categories represents only 9.4% (629 records) of the scientific production in this study.

Table 8 is organised according to subject *ETDEWEB* database and table 9 from the highest to the lowest scientific production subject.

Materials Science, Physics of Elementary Particles and Fields and Plasma Physics and Fusion Technology are the three main subjects of scientific publications within this network, representing, respectively 14.3% (955 records), 13.9% (929 records) and 9.1% (607 records) of the total records of the database (37.4% of records of the database). Of note, the categories "Oil Shale and Tar Sands" and "Knowledge Management and Preservation" have no scientific publications in the period of the study, and "Nuclear Disarmament, Safeguards and Physical Protection" and "Military Technology" only have one resource.

Excluding the first 3 main subjects, all remaining subjects have only up to 6% of representation; the 20 main subjects with more than 1% and 6% represent 53.4% more of the total scientific publications in the energy field.

In sum, although the 3 major subjects represent more than one third of the scientific production, the main conclusion is that more than half of the production is in 20 different subjects, with more than 70 scientific publications in each subject. This indicates that Portuguese scientists have an interest in various subjects within the energy field.

Table: Subjects Category Distribution	#	%
Coal, Lignite and Peat (01) [1]	126	1.9%
Petroleum (02) [1]	34	0.5%
Natural Gas (03) [1]	18	0.3%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	25	0.4%
Hydrogen (08) [3]	44	0.7%
Biomass Fuels (09) [1]	91	1.4%
Synthetic Fuels (10) [3]	9	0.1%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	7	0.1%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	10	0.2%
Hydro Energy (13) [1]	17	0.3%
Solar Energy (14) [1]	74	1.1%
Geothermal Energy (15) [1]	9	0.1%
Tidal and Wave Power (16) [1]	75	1.1%
Wind Energy (17) [1]	38	0.6%
Fossil-Fuelled Power Plants (20) [2]	23	0.3%
Specific Nuclear Reactors and Associated Plants (21) [2]	17	0.3%
General Studies of Nuclear Reactors (22) [2]	13	0.2%
Power Transmission and Distribution (24) [2]	100	1.5%
Energy Storage (25) [2]	10	0.2%
Energy Planning, Policy, and Economy (29) [2]	103	1.5%
Direct Energy Conversion (30) [2]	52	0.8%
Energy Conservation, Consumption, and Utilization (32) [2]	126	1.9%
Advanced Propulsion Systems (33) [4]	8	0.1%
Materials Science (36) [4]	955	14.3%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	382	5.7%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	19	0.3%
Chemistry (40) [4]	58	0.9%
Engineering (42) [4]	145	2.2%
Particle Accelerators (43) [4]	23	0.3%
Instrumentation (44) [4]	81	1.2%
Military Technology (45) [4]	1	0.0%
Instrumentation Related to Nuclear Science and Technology (46) [4]	243	3.6%
Other Instrumentation (47) [4]	6	0.1%
Environmental Sciences (54) [4]	265	4.0%
Biology and Medicine (55) [4]	28	0.4%
Biology and Medicine (56) [4]	17	0.3%
Geosciences (58) [4]	43	0.6%
Applied Life Sciences (60) [4]	130	2.0%
Radiation Protection and Dosimetry (61) [4]	91	1.4%
Radiology and Nuclear Medicine (62) [4]	141	2.1%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63) [4]	18	0.3%
Physics (66) [4]	179	2.7%
Plasma Physics and Fusion Technology (70) [4]	607	9.1%
Classical and Quantum Mechanics, General Physics (71) [4]	364	5.5%
Physics of Elementary Particles and Fields (72) [4]	929	13.9%
Nuclear Physics and Radiation Physics (73) [4]	333	5.0%
Atomic and Molecular Physics (74) [4]	120	1.8%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	373	5.6%
Nanoscience and Nanotechnology (77)[4]	8	0.1%
Astronomy, Cosmology and Astrophysics (79)[4]	30	0.5%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	11	0.2%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	1	0.0%
General and Miscellaneous (99) [4]	32	0.5%
Total	**6662**	**100.0%**

Table 8: Subjects category distribution per subject order within the ETDEWEB (1995-2010)

Table: Subjects Category Distribution sorted	#	%
Materials Science (36) [4]	955	14.3%
Physics of Elementary Particles and Fields (72) [4]	929	13.9%
Plasma Physics and Fusion Technology (70) [4]	607	9.1%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	382	5.7%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	373	5.6%
Classical and Quantum Mechanics, General Physics (71) [4]	364	5.5%
Nuclear Physics and Radiation Physics (73) [4]	333	5.0%
Environmental Sciences (54) [4]	265	4.0%
Instrumentation Related to Nuclear Science and Technology (46) [4]	243	3.6%
Physics (66) [4]	179	2.7%
Engineering (42) [4]	145	2.2%
Radiology and Nuclear Medicine (62) [4]	141	2.1%
Applied Life Sciences (60) [4]	130	2.0%
Coal, Lignite and Peat (01) [1]	126	1.9%
Energy Conservation, Consumption, and Utilization (32) [2]	126	1.9%
Atomic and Molecular Physics (74) [4]	120	1.8%
Energy Planning, Policy, and Economy (29) [2]	103	1.5%
Power Transmission and Distribution (24) [2]	100	1.5%
Biomass Fuels (09) [1]	91	1.4%
Radiation Protection and Dosimetry (61) [4]	91	1.4%
Instrumentation (44) [4]	81	1.2%
Tidal and Wave Power (16) [1]	75	1.1%
Solar Energy (14) [1]	74	1.1%
Chemistry (40) [4]	58	0.9%
Direct Energy Conversion (30) [2]	52	0.8%
Hydrogen (08) [3]	44	0.7%
Geosciences (58) [4]	43	0.6%
Wind Energy (17) [1]	38	0.6%
Petroleum (02) [1]	34	0.5%
General and Miscellaneous (99) [4]	32	0.5%
Astronomy, Cosmology and Astrophysics (79)[4]	30	0.5%
Biology and Medicine (55) [4]	28	0.4%
Isotopes and Radiation Sources (07) [1]	25	0.4%
Fossil-Fuelled Power Plants (20) [2]	23	0.3%
Particle Accelerators (43) [4]	23	0.3%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	19	0.3%
Natural Gas (03) [1]	18	0.3%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63) [4]	18	0.3%
Hydro Energy (13) [1]	17	0.3%
Specific Nuclear Reactors and Associated Plants (21) [2]	17	0.3%
Biology and Medicine (56) [4]	17	0.3%
General Studies of Nuclear Reactors (22) [2]	13	0.2%
Mathematical Methods and Computing (97)[4]	11	0.2%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	10	0.2%
Energy Storage (25) [2]	10	0.2%
Synthetic Fuels (10) [3]	9	0.1%
Geothermal Energy (15) [1]	9	0.1%
Advanced Propulsion Systems (33) [4]	8	0.1%
Nanoscience and Nanotechnology (77)[4]	8	0.1%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	7	0.1%
Other Instrumentation (47) [4]	6	0.1%
Military Technology (45) [4]	1	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	1	0.0%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0%
Total	**6662**	**100%**

Table 9: Subjects category distribution sorted by number of publications (1995-2010)

As Laband and Tolisson (2000) argue, it is important to analyse the incidence of co-authorship (proportion of articles of multiple authors) and the extent of co-authorship (average number of authors of co-authored articles). Table 10 shows this type of analysis, highlighting the fact that only 8.2% of the resources are single author publications and publications by three authors are the most common type of co-authorship, with 22.7%. Therefore the incidence of co-authorship is extremely high at 91.8%.

As mentioned above, Nathan et al (1998) considered, for social sciences, that more than four authors per article were too many. In this study, articles with more than four authors represent 37.1%, more than one third of the records.

This high figure is explained by the tendency of energy field subjects to be complex and therefore have multidisciplinary and multi-nationality teams. In fact, a very high number of scientific publications is seen in the database with multiples teams within the EURATOM Association; 17 journal articles that have more than 50 authors and one has 116 authors.

In the next chapter the social network analysis will only consider the resources that have up to 20 authors, which represents 98.8% of the dataset.

Table: Number of Authors per Resource	#	%
1	546	8.2%
2	1097	16.5%
3	**1513**	**22.7%**
4	1033	15.5%
5	713	10.7%
6	502	7.5%
7	317	4.8%
8	246	3.7%
9	162	2.4%
10	94	1.4%
11	61	0.9%
12	48	0.7%
13	24	0.4%
14	33	0.5%
15	31	0.5%
16	21	0.3%
17	22	0.3%
18	14	0.2%
19	23	0.3%
20	80	1.2%
>= 21	82	1.2%

Table 10: Number of Authors per resource (1995-2010)

Table 11 shows that the average number of authors per resource, from 1995 to 2010, is always higher than 3 authors per publication. In the last 6 years, the average is equal or higher than 5 authors and we can see a clear trend of increase in the average number of authors per publication from around 4 in 1995 and more than 6 in 2009.

Table: Average Number of Authors per Resource (per year)	
1995	3.9
1996	4.2
1997	4.1
1998	4.3
1999	4.1
2000	4.2
2001	4.3
2002	4.5
2003	4.5
2004	4.5
2005	5.0
2006	5.3
2007	5.5
2008	6.3
2009	6.5
2010	5.9

Table 11: Average number of Authors per resource (1995-2010)

In order to analyse the extent of co-authorship in publications that have more than one author, all the single-author resources were not considered, to assess the true extent of co-authorship.

Table 12 shows that the average number of authors per resource in co-authorship, from 1995 to 2010, is always higher than 4 authors per paper. In the last 7 years, the average is equal or higher than 5 authors, and in the last 3 years it is higher than 6 authors. The average number of authors per resource considering for this period is of 5.5 authors.

Table: Average Number of Authors per Resource (per year)	
1995	4.2
1996	4.6
1997	4.4
1998	4.8
1999	4.6
2000	4.5
2001	4.6
2002	4.9
2003	4.9
2004	5.0
2005	5.3
2006	5.6
2007	5.8
2008	6.6
2009	6.9
2010	6.2

Table 12: Average number of Authors per resource per year (1995-2010)

Chapter 6 – The Application of Social Network Analysis to the ETDEWEB

Based on the *ETDEWEB* data, processed as briefly described in chapter 4, a social network preliminary analysis of the co-authorship relationships within the energy field, among scientists working in Portugal and Portuguese scientists having affiliations in foreign R&D institutions, was carried out for the period from 1995 to 2007, the period 2008 to 2010 was excluded to time and technical constraints. The social network maps were built, using the *NetDraw* application (Borgatti, 2002).

NetDraw is a program of drawing networks. It is a free stand-alone software tool for displaying social networks, but is also distributed with *UCINET*.

This software uses several different algorithms for displaying nodes in a two-dimensional space, using a circle layout or layouts obtained with multidimensional scaling or spring embedding. These layouts are based on geodesic distance. It has tools for grouping and automatically recoloring, resizing, or reshaping of nodes, ties and labels to represent these groups. Graphs can be rotated, flipped, resized, and saved in several formats, amongst others, as bitmap (BMP) and JPEG files. Export functions to *Mage* and *Pajek* are available. *NetDraw* includes some analysis procedures, for example, identification of isolates, components, or k-cores, the results of which are displayed graphically (Huisman, 2003).

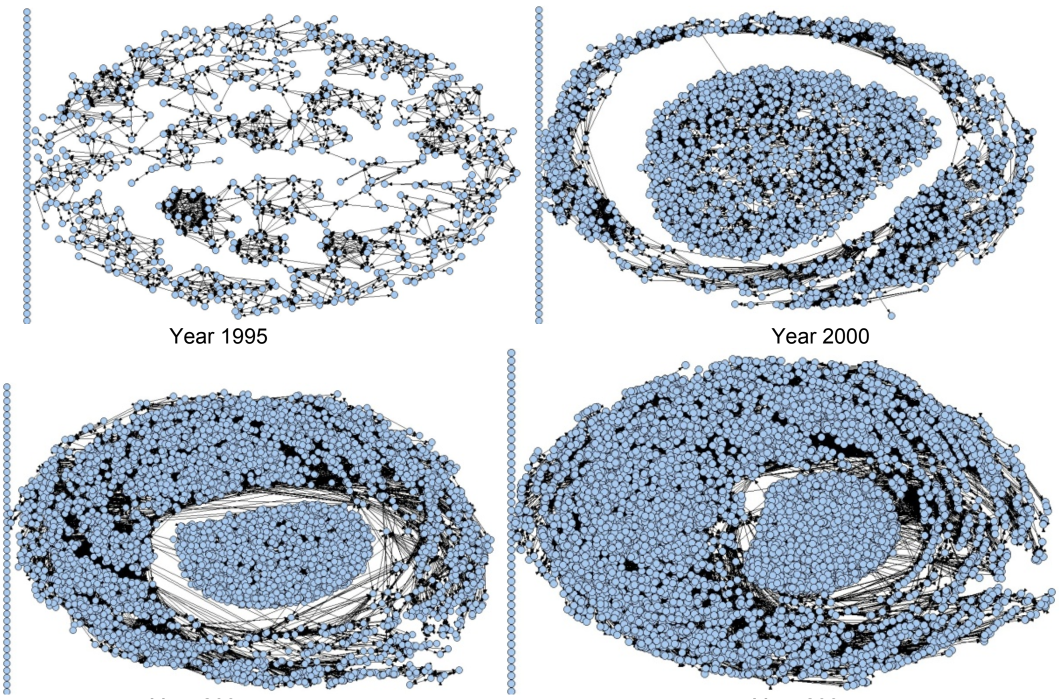


Figure 7: Energy field community co-authorship social network evolution (1995-2007)

Figure 7 graphically illustrates the evolution of the social network in terms of actors (authors) and the relationships they have established. Each year, the social network map represents the cumulative co-authorships from 1995 up to the reference year. The figure represents the snapshot of the year 1995, 2000, 2005 and 2007.

The first conclusion that one can draw is the increase in co-authorship, which validates the trend mentioned by various authors (Acedo et al, 2006) and validates the previously noted tendency to cooperation when addressing complex problems in the contemporary world (Hara et al, 2003).

The nodes represent the social network actors, i.e. the scientists of the energy field working in Portugal and those whose affiliation is abroad. In this case, the nodes do not have any attribute.

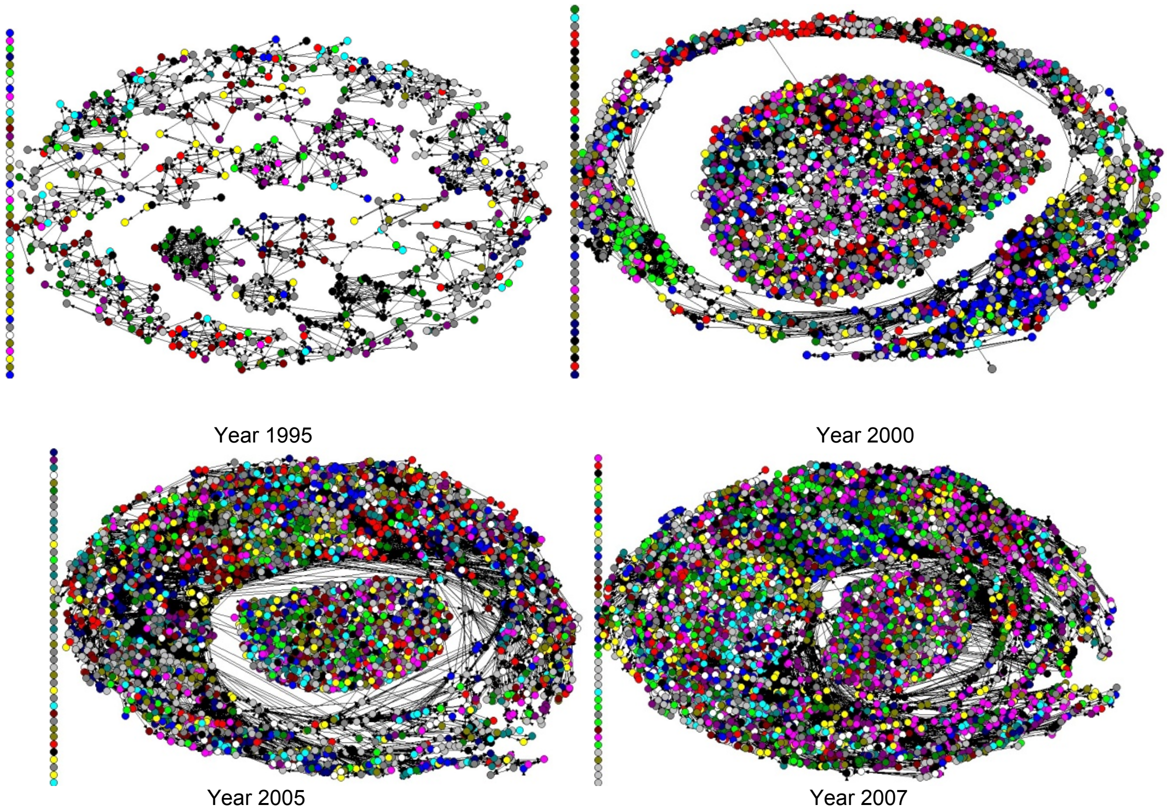


Figure 8 : Energy field community co-authorship social network evolution (1995-2010) – node attribute - institution

In figure 8, we have the same evolution of the social network, but the nodes colour show the main institution attribute, based on the node colour and the lines represent the co-authorship relationships. Although the colour represents the institution, we cannot make the comparison here between the years because of the large number of scientists and institutions which are represented.

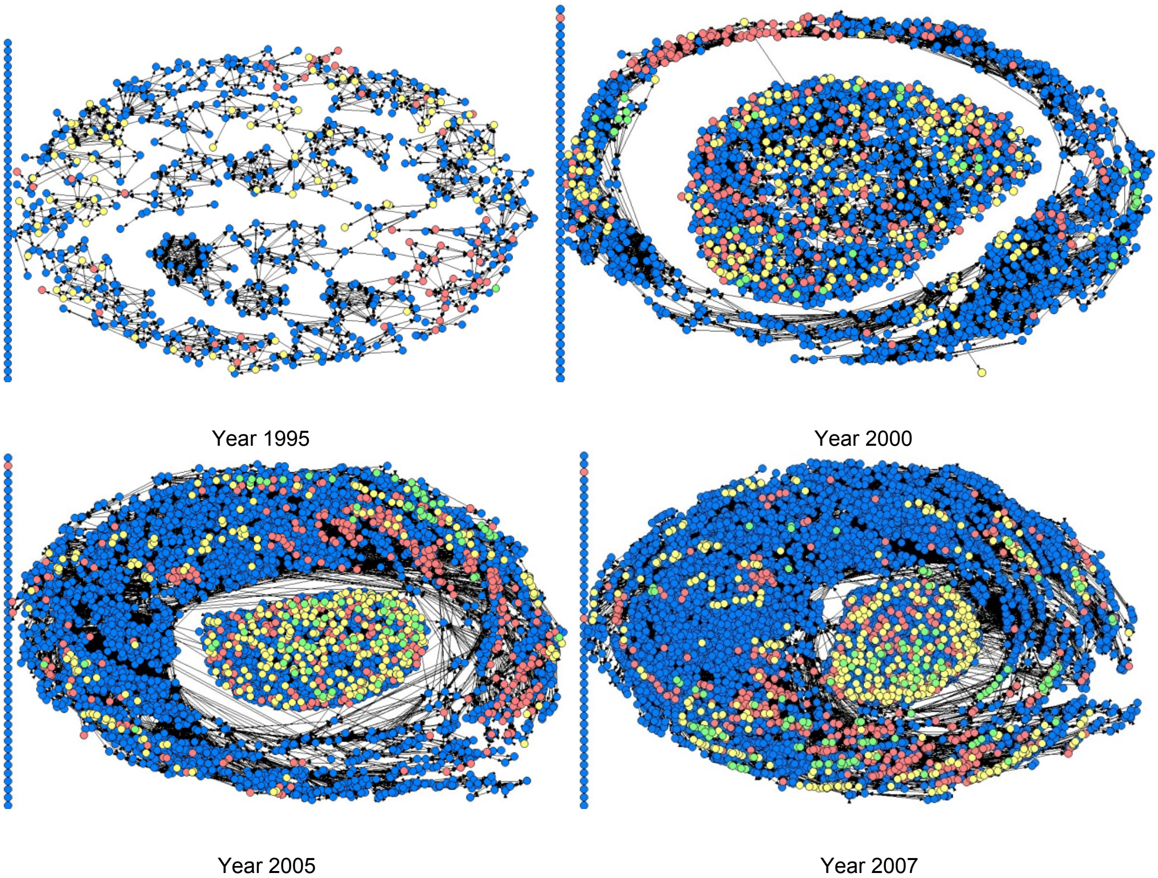
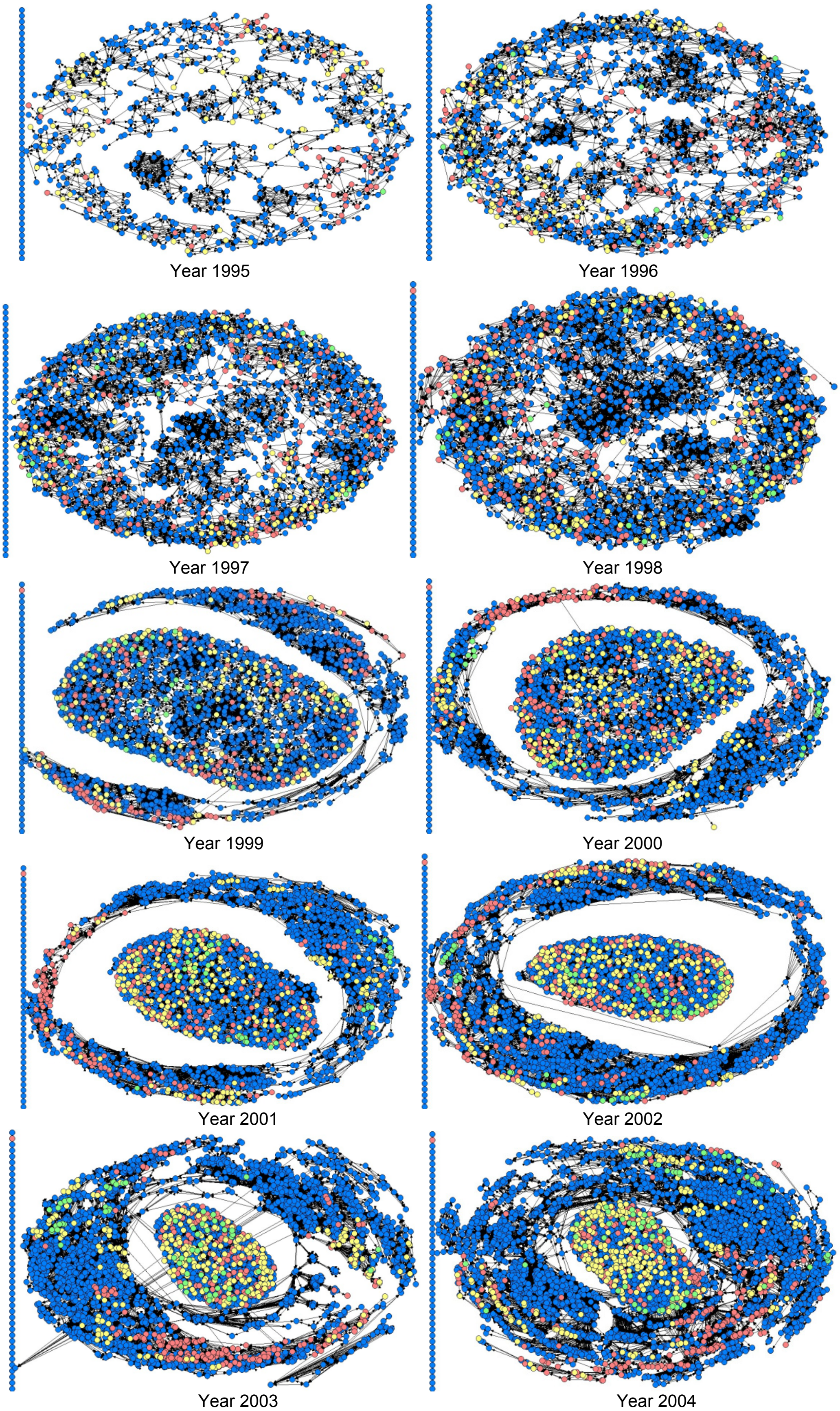


Figure 9: Energy field community co-authorship social network evolution (1995-2010) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

Figure 9 shows the same evolution of the social network, but the nodes colour show the main subject attribute, based on the node colour and the lines represent the co-authorship relationships. The conclusions are that the authors have as main subject the one related to basic information developed in support of energy production (main subject 4).

Because the node attribute, main subject, allows having more information than the node attribute, main institution, the maps that follow will be presented with this node attribute.


Year 1995
Year 1996
Year 1997
Year 1998
Year 1999
Year 2000
Year 2001
Year 2002
Year 2003
Year 2004

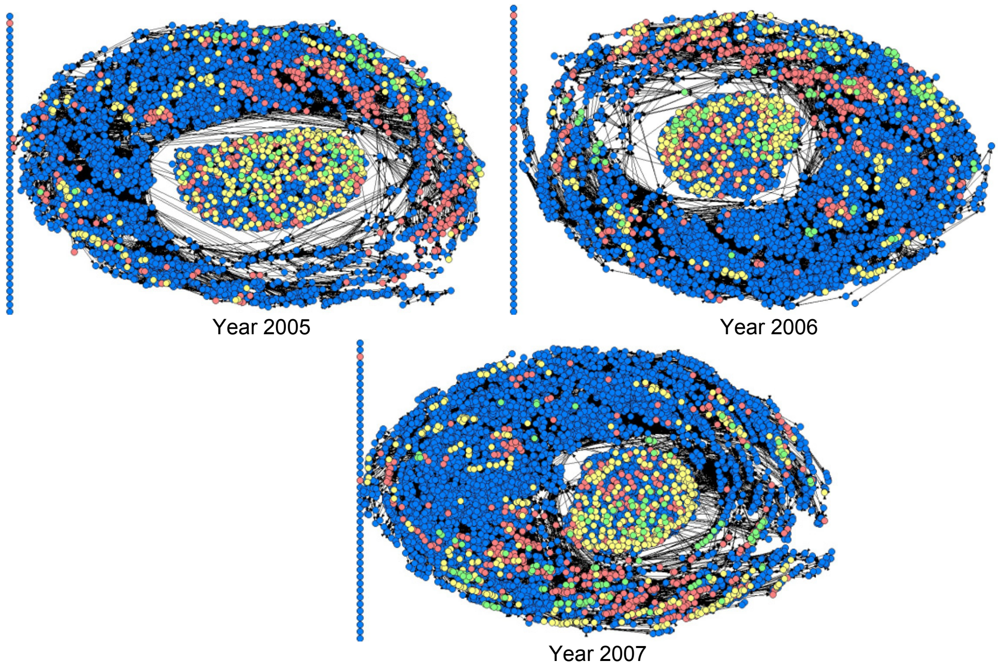


Figure 10: Energy field community co-authorship social network evolution (1995-2007) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

In figure 10, we have the evolution of the social network, considering the period 1995-2007, with the nodes colour showing the main subject attribute.

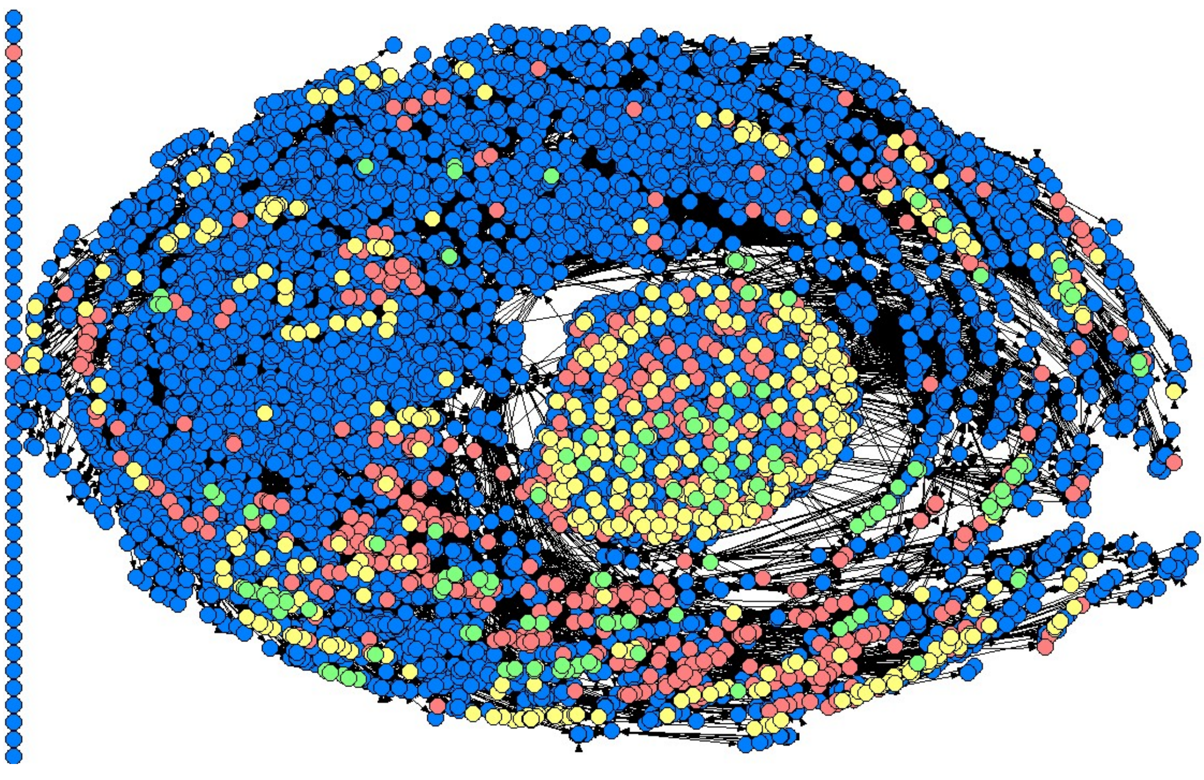


Figure 11: Energy field community co-authorship social network 2007 cumulative

One can further analyse some specific paths, through which collaboration occurred, using some of the centrality measures.

Centrality is a structural attribute of nodes in a network; using this measure, we can get some idea of the importance, influence and prominence of an actor in the network. According to Kilduff and Tsai, (2003) one can determine the relative importance of an actor by examining one of the following network characteristics:

- has many ties to other actors – degree centrality;
- is able to reach many actors – closeness centrality;
- connects to other actors who have no direct connections – betweenness centrality;
- is connected to many actors who are themselves connected to many other actors – eigenvector centrality.

Cumulative co-authorship relationships, from 1995 until 2007, were used in the centrality analysis.

Figure 12 illustrates the co-authorship social network, where the node size represents the degree of centrality and indicates the number of links incident upon a node. This indicator does not take into account the strength of direct links between the two actors; it only reveals the number of people with whom any one scientist has collaborated. This represents access to information and can be considered as a hub or a connector in this network.

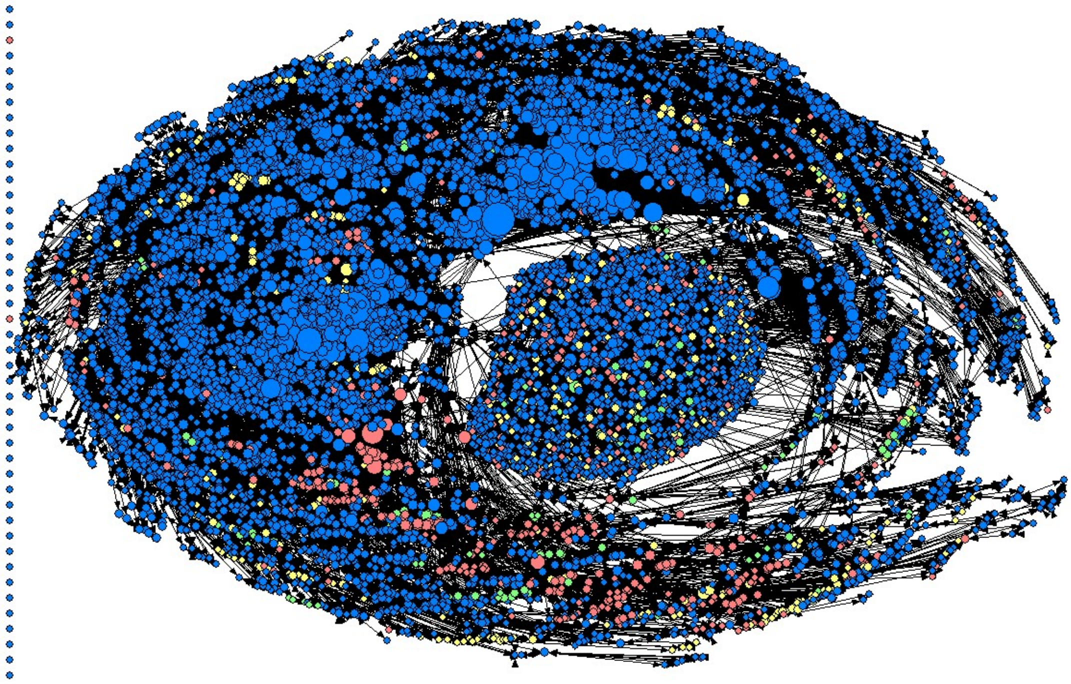


Figure 12: degree centrality - Energy field community co-authorship social network 2007 cumulative

Figure 13 represents the same co-authorship network, where the node size represents the closeness centrality, which defines paths to the other actors. This represents the capability to monitor the information flow in the network and therefore the network activity.

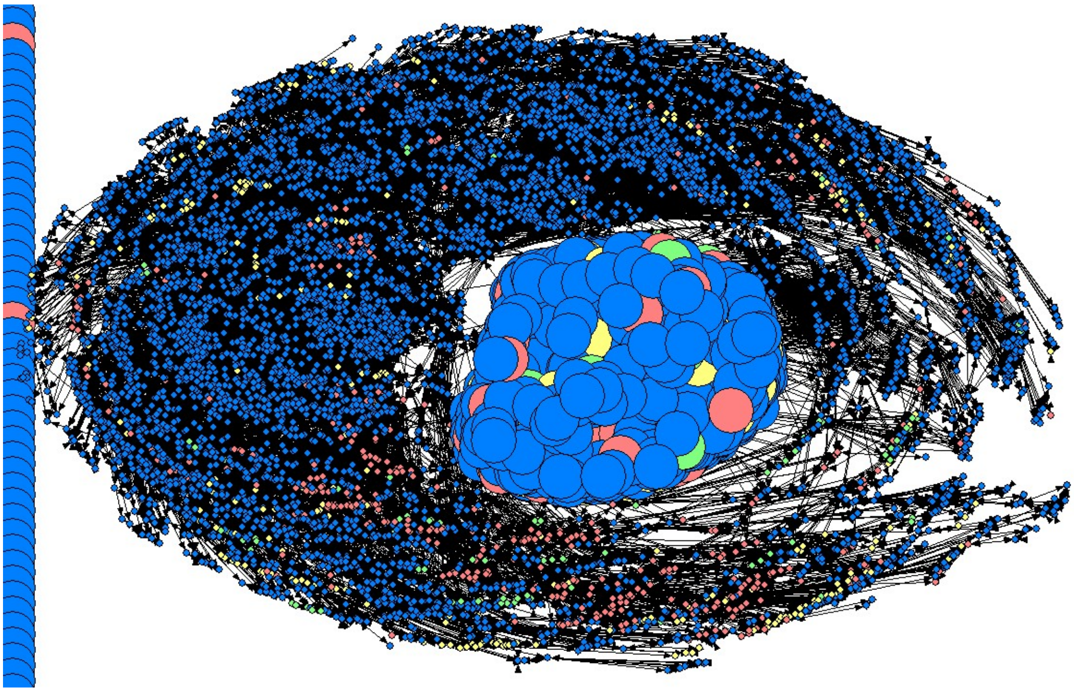


Figure 13: closeness centrality - Energy field community co-authorship social network 2007 cumulative

Figure 14 illustrates the betweenness centrality, which is seen as the number of geodesic paths that goes through a node, expressed as a measure of centrality. This reflects the capacity of an author to connect with other authors in the network, i.e., it is a measure of an author's ability to perform a "broker" role within the network (Acedo et al., 2006).

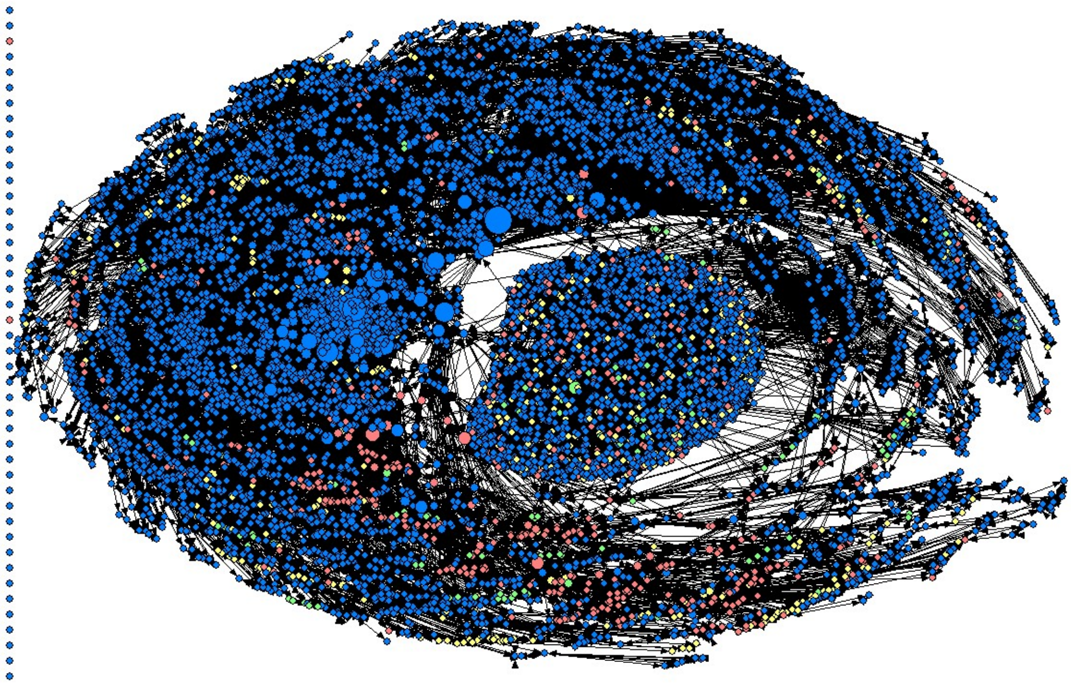


Figure 14: betweenness centrality - Energy field community co-authorship social network 2007 cumulative

Figure 15 illustrates the eigenvector centrality, which is seen as the importance of a node in the network. An actor with a high eigenvector centrality is connected to many other actors, who themselves are well connected and are therefore the most likely to be receiving new ideas.

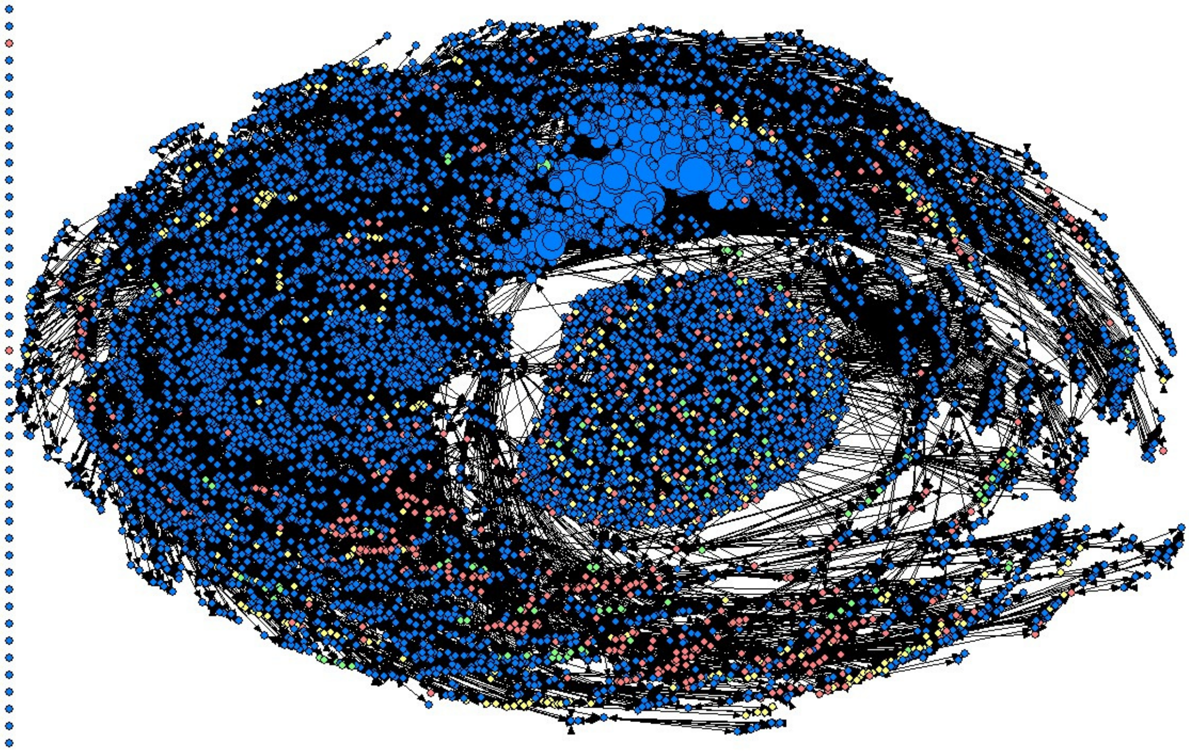


Figure 15: eigenvector centrality - Energy field community co-authorship social network 2010 cumulative

Table lists the information displayed pictorially in the graphs above, in terms of the authors of the highest number of papers, degree, betweenness and eigenvector. The closeness centrality is not shown in this table, because there are too many authors with the same closeness, making it difficult to choose a top 10.

Table: The authors with highest number of papers, degree, betweeness and eigenvector (1995-2007)

Number of papers			Degree			Betwenness			Eigenvector		
106	Abreu,P.	IST - UTL	229	Alves,E.	ITN	3152510	Alves,E.	ITN	0.197	Nave,M.F.F.	EURATOM IST - UTL
103	Adam,W.	AAS	165	Nave,M.F.F.	EURATOM IST - UTL	1691909	Varandas,C.A.F.	EURATOM IST - UTL	0.168	Borba,D.N.	EURATOM IST - UTL
92	Alves,E.	ITN	160	Varandas,C.A.F.	EURATOM IST - UTL	1412103	Barradas,N.P	ITN	0.156	Luna,E.dela	EURATOM CIEMAT
91	Gulyurtlu,I.	INETI	156	Barradas,N.P	ITN	1217266	Amaral,V.S.	UAv	0.155	Lomas,P.J.	EURATOM UKAEA
82	Varandas,C.A.F.	EURATOM IST - UTL	150	Silva,C.G.	EURATOM IST - UTL	1127379	Carvalho,P.	EURATOM IST - UTL	0.154	Mantsinen,M.J.	EURATOM TEKES
78	Cabrita,I.	INETI	136	Borba,D.N.	EURATOM IST - UTL	1098431	Fortunato,ElviraM.C.	UNL	0.146	Kiptily,V.G.	EURATOM UKAEA
77	Providencia,C.	UC	116	Conway,G.D.	EURATOM IPP	1088652	Reis,M.A.	ITN	0.142	Alper,B.	EURATOM UKAEA
72	Providencia,J.da	UC	115	Fortunato,ElviraM.C.	UNL	1058830	Teixeira,V.	UMi	0.141	Sharapov,S.E.	EURATOM UKAEA
68	Mendonca,J.T.	IST - UTL	111	Sousa,J.B.	UP	933251	Pereira,L.	UNL	0.139	Baar,M.de	EURATOM FOM
67	Freitas,M.C.	ITN	110	Amaral,V.S.	UAv	863510	Vieira,J.	IST - UTL	0.134	Noterdaeme,J.M.	EURATOM IPP

Table 13: The authors with the highest degree, betweeness and eigenvector (1995-2007)

The scientists of the following institutions are very active in this energy field: 7 Institutions of the EURATOM Association, *Instituto Tecnológico e Nuclear*, *Instituto Superior Técnico* of *Universidade Técnica de Lisboa*, Austrian Academy of Sciences, *INETI* (now known as *LNEG*), *Universidade Nova de Lisboa*, *Universidade do Porto*, *Universidade de Coimbra*, *Universidade de Aveiro* and *Universidade do Minho*.

Chapter 7 – Conclusions, Limitations and Further Research

Hara et al. (2003) pointed out how in science and technology the effect of scientific cooperation is significant when addressing complex problems in the contemporary world of "rapidly changing technology, dynamic growth of knowledge and highly specialized areas of expertise" and Chun et al. (2006) state that this cooperation among researchers continues to increase in every scientific field and not only in science and technology studies.

Various difficulties complicate the direct assessment of scientists' contributions to research, but using the number of co-authors as one method to measure collaboration and to assess relationships between researchers has its advantages, as Subramanyam (2003) highlights: it is invariant, quantifiable, easy and inexpensive to discover. It is also, non-reactive (meaning that the process of determining the extent of collaboration does not have impact on the process of collaboration itself, as for example methods of observation, interviews or questionnaires do).

As we proposed in the beginning of this study, we have identified the evolution of co-authorship in the period 1995-2010 and evaluated the productivity of the science-field in terms of co-authorship. Following that we validated the social structure that exists in the energy and the dominant researchers/institutions within.

Hence, the major conclusions of this study are:

- Journal articles and conference proceedings represent 82.6% and 17.4%, respectively;
- The growth of scientific production in the energy field is similar to the growth of the Portuguese scientific production in the similar field of technology and engineering sciences, in both periods, 2000-2009 and 2004-2009, with 154% and 46% respectively;
- The years 1995-2010 saw a higher scientific production of journal articles than conference proceedings. The difference between conference proceedings and journal articles is very high (at more than 200 scientific publications) in the years 2002-2010, whereas in the years 1995 and 1999-2001, a smaller difference of less than 70 scientific publications is noted;

- Materials Science, Physics of Elementary Particles and Fields and Plasma Physics and Fusion Technology are the three main subjects of scientific publications within this network;

- Only 8.2% of the resources are single author publications and publications by three authors are the most common type of co-authorship, with 22.7%. Therefore the incidence of co-authorship is extremely high at 91.8%;

- The average number of authors per resource in co-authorship, from 1995 to 2010, is always higher than 4 authors per paper. In the last 7 years, the average is equal or higher than 5 authors and in the last 3 years is higher than 6 authors. The average number of authors per resource for the period is of 5.5 authors;

- The social network within the energy-field is made up of 12,843 different authors from 1,528 different main organizations;

- The following institutions have a prominent influence within the network of the energy field: 7 Institutions of the EURATOM Association, *Instituto Tecnológico e Nuclear*, *Instituto Superior Técnico* of *Universidade Técnica de Lisboa*, Austrian Academy of Sciences, *INETI* (now known as *LNEG*), *Universidade Nova de Lisboa*, *Universidade do Porto*, *Universidade de Coimbra*, *Universidade de Aveiro* and *Universidade do Minho*.

The biggest limitation in the study refers to the database used: the *ETDEWEB* database. This database is not prepared for an immediate use for bibliometrics and social network analysis, as the author and its affiliation were not standardized, mainly because there are no specific rules for data introduction of the author and institution in this field. Due to this major part for this study was conducted based on standardization of the database instead of a more in-depth analysis.

Another limitation was the size of the network study, since the energy field in Portugal is a large-scale network with various authors and various institutions, which made visual interpretation more difficult; as such we could only analyse trends.

Having said this, using this study and the standardized database as a starting point, further research could be done, like the length of the article as a variable, a more thin subject within the energy-field, the study of a single institution or of a single country. The first future research must be to complete the social network analysis to include the period between 2008 and 2010.

As Piette and Ross (1992) pointed out, the article length is a relevant factor because of the institutional pressure on researchers to increase their productivity by publishing scientific work and the fierce competition for the finite space available in scientific journals. Therefore, in a further research the length of the articles should be analysed and to check if in the energy-field the length of the articles is greater for co-authored than for single-authored publications, as pointed out in similar works (Laband and Tollison, 2000) to this study.

Accordingly to Klitkou et al. (2007) and Hassan (2003), a keyword approach could be used to map networks for specific knowledge areas within the energy field, as was done to fuel cells and related hydrogen technology. Considering the data set of this study one approach of study could be analysing in depth one or more subject categories, such as the three categories with most scientific production in the period 1995-2010: Plasma Physics and Fusion Technology, Materials Science and Physics of Elementary Particles and Fields – study this subset. Since the initial database has keywords associated to each record, a study of smaller areas of interest within these three subjects is possible.

Melin and Persson (1996) pointed out that various aggregations levels, article analysis and network analysis can be used. They conducted a study for a university, Umea University, for various forms of authorship (authored by a single department, internally co-authored, nationally co-authored, nationally and internationally co-authored and internationally co-authored), making a comparison with the external type of institution (university, government institutes, hospitals, industries, private institutes), split as national and international, or by field; and they also made a study of a single country, Sweden, with the number of co-authorships by major field and by country, with major science regions (EU-countries, North America, Nordic Countries). This study could be replicated for Portugal as a whole and for an institution, such as the *EURATOM Instituto Superior Tecnico*, *Instituto Tecnologico e Nuclear* or other that appeared with authors in the top 10 of the social network analysis centralities table 13 in chapter 6.

References

Abramo, G., D'Angelo, C.A., Di Costa, F., Solazzi, M. (2009). University-industry collaboration in Italy: A bibliometric examination. *Technovation,* 29, 498-507.

Abramo, G., D'Angelo, C.A., Solazzi, M. (2010). Assessing public-private research collaboration: is it possible to compare university performance?. *Scientometric*s, 84, 173-197.

Acedo, F. J., Barroso, C., Casanueva, C., Galán, J.L. (2006). Co-Authorship in Management and Organizational Studies: An Empirical and Network Analysis. *Journal of Management Studies,* 43(5), 957-983.

Ahearn, M. (2000). ETDEWEB - Database Web Site. *The Forestry Chronicle*, 76(3), 404.

Allen, J., James, A.D., Gamlen, P. (2007). Formal versus informal knowledge networks in R&D: a case study using social network analysis. *R&D Management,* 37(3), 179-196.

Barabási, A.L., Jeong, H., Néda, Z., Ravasz, E., Schubert, A. Vicsek, T. (2002). Evolution of the social network of scientific collaborations. *Physica A,* 311, 590-614.

Bar-Ilan, J. (2008). Informetrics at the beginning of the 21st century - a review. *Journal of Informetrics,* 2, 1-52.

Barnet, A. H. et al (1988). The Rising Incidence of co-authorship in economics: further evidence. *Review of Economics and Statistics*, *70*(3), 539-543.

Batagelj, V. (2008). Social Network Analysis, Large-scale. Ljubljana. Slovenia: University of Ljubljana.

Beaudry, C., Schiffauerova, A. (2011). Impacts of collaboration and network indicators on patent quality: The case of Canadian nanotechnology innovation. *European Management Journal*, 29, 362-376.

Beaver, B., Rosen, R. (1978), Studies in scientific collaboration: Part I--The professional origins of scientificco-authorship. *Scientometrics,* 1,65-84

Beaver, B., Rosen, R. (1979a), Studies in scientific collaboration: Part II--Scientific co-authorship, research productivity and visibility in the French scientific elite. *Scientometrics* 1,133-149.

Beaver, B., Rosen, R. (1979b), Studies in scientific collaboration: Part III--Professionalization and the natural history of modern scientific co-authorship. *Scientometrics*, 1,231-245.

Bettencourt, L.M.A., Kaiser, D.I., Kaur, J. (2009). Scientific discovery and topological transitions in collaboration networks. *Journal of Informetrics*, 3, 210-221.

Borgatti, S. P. (2002). *Netdraw: Graph Visualization Software*. Harvard Analytic Technologies [http://www.analytictech.com/Netdraw/netdraw.htm] last accessed 30 November 2011.

Borgatti, S.P. (2005). Centrality and network flow. *Social Networks*, 27, 55-71.

Borgatti, S.P., Foster, P.C. (2003). The Network Paradigm in Organizational Research: A Review and Topology. *Journal of Management*, 29(6), 991-1013.

Borgatti, S.P., Mehra, A., Brass, D.J., Labianca, G. (2009). Network Analysis in the Social Sciences. *Science,* 323, 892-895.

Bozeman, B., Corley, E. (2004). Scientist's collaboration strategies: implications for scientific and technical human capital. *Research Policy*, 33, 599-616.

Breiger, R.L. (2004). *The Analysis of Social Networks.* London: Sage Publications.

Casseres, B., Hagedoorn, J., Jaffe, A. (2006). Do alliances promote knowledge flows?. *Journal Financial Economics,* 80, 5-33.

Chen, C. Panjwani, G., Proctor, J., Allendoerfer, K., Kuljis, J., Aluker, S., Sturtz, D., Vukovic, M. (2006) Visualizing the Evolution of HCI. Philadelphia, USA: College of Information Science and Technology, Drexel University.

Chiu, D., Fu, T.Z.J. (2010). "Publish or Perish" in the Internet Age. *ACM SIGCOMM Computer Comunnication Review,* 40, 34-43.

Chun-juan, L., Hai-yan, H., Xu-kun, W., Ze-yuan, L. (2007). Study on the Structure of Inventors' Collaboration Networks in the Field of International Digital Information Transmission in 2006. *2007 International Conference on Management Science & Engineering (14th),* 71-78.

Clark, L. (2006). Network Mapping as a Diagnostic Tool Manual. La Paz, Bolívia: Centro Internacional de Agricultura Tropical.

Cotta, C., Merelo, J. (2007). Where is evolutionary computation going? A temporal analysis of the EC community. *Genet Program Evolvable Mach,* 8, 239-253.

Coulon, F. (2005). The use of Social Network Analysis in Innovation Research: A literature review. Swedwn: Lund University.

Creswick, N., Westbrook, J. (2010). Social network analysis of medication advice-seeking interactions among staff in an Australian hospital. *International Journal of Medical Informatics*, 79, e116-e125.

Cross, R., Borgatti, S.P., Parker, A. (2001). Beyond answers: dimensions of the advice network. *Social Networks,* 23, 215-235.

Cross, R., Borgatti, S.P., Parker, A. (2002) Making Invisible Work Visible: Using Social Network Analysis to Support Strategic Collaboration.

Cross, R., Liedtka, J., Weiss, L. (2005). A Practical Guide to Social Networks. *Harvard Business Review,* 124-132.

Cross, R., Nohria, N., Parker, A. (2002). Six Myths About Informal Networks - and How To Overcome Them. *MITSloan Management Review*, 43(3), 67-75.

Cross, R., Parker, A., Prusak, L., Borgatti, S.P. (2001) Knowing What We Know: Supporting Knowledge Creation and Sharing in Social Networks.

Cutler, D.E., (1999). Grey Literature in Energy: 5 Years Later. Office of Scientific and Technical Information.

Cutler, D.E., (2010). ETDEWEB versus the World-Wide-Web: A Specific Database/Web Comparison. Office of Scientific and Technical Information.

Damian, D., Marczak, S., Kwan, I. (2007). Collaboration Patterns and the Impact of Distance on Awareness in Requirements-Centred Social Networks. *15th IEEE International Requirements Engineering Conference,* 59-68.

Donato, H., Oliveira, C.F. (2009). Bibliometria do Cancro em Portugal 1997 a 2006. Acta Med Port, 22, 41-50.

Donato, H.M., Oliveira, C.F. (2006). Patologia Mamária - Avaliação da Actividade Científica Nacional através de Indicadores Bibliométricos (1995 Julho 2005). *Acta Med Port,* 19, 225-234.

Ferreira, A. S., Neto, M. C., & Fernandes, C. (2011). Evaluating external researchers impact on a research community social capital with social network analysis. Paper presented at the 6ª Conferência Ibérica de Sistemas e Tecnologias de Informação, Chaves.

Fortunato, S. (2010). Community detection in graphs. *Physics Reports*, 486, 75-174.

Frame, J.D., Carpenter, M.P. (1979) in Subramanyam, K. (1983), Bibliometric studies of research collaboration: A review, *Journal of Information Science*

Glänzel, W., Schlemmer, B., Schubert, A., Thijs, B. (2006). Proceedings literature as additional data source for bibliometric analysis. *Scientometrics,* 68, 457-473.

Glänzel, W., Schubert, A. (2004). *Handbook of Quantitative Science and Technology Research*, 11, 257-276.

GPEARI/MEC. (2010). *Produção Científica Portuguesa, 1990-2009: Séries Estatísticas.* Lisboa: GPEARI/MEC.

GPEARI/MEC. (2011). *Produção Científica Portuguesa, 1990-2010: Séries Estatísticas.* Lisboa: GPEARI/MEC.

Haas, M. (2009). Social network theory and analysis: a preliminary exploration. Sydney: faculty of Business, University of Technology.

Han, S., Kim, B.J. (2008). Network analysis of an online community. *Physica A*, 387, 5946-5951.

Hara, N., Solomon, P., Kim, S., Sonnenwald, D.H. (2003) An Emerging View of Scientific Collaboration: Scientists' Perspectives on Collaboration and Factors that Impact Collaboration. *Journal of the American Society for Information Science and Technology,* 54(10), 952-956.

Hassan, E. (2005). The evolution of the knowledge structure of fuel cells. *Scientometrics,* 65(2), 223-238.

Heffner, A.G. (1981). Funded research, multiple authorship, and subauthorship collaboration in four disciplines. *Scientometrics*, 3, 5–12.

Hellström, T., Husted, K. (2003). Mapping Knowledge and Intellectual Capital in Academic. Copenhagen, Denmark: Department of Management, Politics and Philosophy.

Hu, C., Racherla, P. (2008). Visual representation of knowledge networks: A social network analysis of hospitality research domain. *International Journal of Hospitality Management,* 27, 302-312.

Huisman, M., Duijn, M.A.J. (2003). Software for Social Network Analysis. Groningen: University of Groningen.

Hwang, S., Wei, C., Liao, Y. (2010). Coauthorship networks and academic literature recommendation. *Journal Electronic Commerce Research and Applications,* 9(4), 323-334.

Joseph, K., Laband, D., Patil, V. (2005). Author Order and Research Quality. *Southern Economic Journal*, 71(3), 545-555.

Kang, I., Na, S., Lee, S., Jung, H., Kim, P., Sung, W. Lee, J. (2009). On co-authorship for author disambiguation. *Information Processing and Management,* 45, 84-97.

Kang, J.O., Park, S.H., Park, Y. (2011). The Analysis of Co-authorship and Networks among the Korean Pathologists. *The Korean Journal of Pathology,* 45, 227-236.

Kastelle, T., Steen, J. (2010). Using network analysis to understand innovation. *Innovation: management, policy & practice,* 12, 2-4.

Katz, J. & Martin, B. R. (1997). What is research collaboration?. Research Policy, No 26, 1-18.

Klitkou, A., Nygaard, S., Meyer, M. (2007). Tracking techno-science networks: A case study of fuel cells and related hydrogen technology R&D in Norway. *Scientometrics*, 70(2), 491-518.

Kretschmer, H., Aguillo, I. (2004). Visibility of collaboration on the Web. *Scientometrics*, 61(3), 405-426.

Kurosawa, T., Takama, Y. (2011). Redicting Researchers' Future Activities using Visualization System for Co-Authorship Networks. *IEEE/WIC/ACM International Conferences on Web Intelligence Agent Technology*, 332-339.

Laband, D.N., Piette, M.J. (1994). Favoritism versus Search for Good Papers: Empirical Evidence Regarding the Behaviour of Journal Editors. *The Journal of Political Economy,* 102(1), 194-203.

Larsen, K. (2008). Knowledge network hubs and measures of research impact, science structure, and publication output in nanostructured solar cell research. *Scientometrics,* 74(1) 123-142.

Li-gun, Y., Kretschmer, H., Hanneman, R.A., Ze-yuan, L. (2006). Coonection and stratification in research collaboration: An analysis of the COLLNET network. *Information Processing and Management,* 42, 1599-1613.

Liu, X., Bollen, J., Nelson, M.L., Sompel, H.V. (2005). Co-authorship networks in the digital library research community. *Information Processing and Management,* 41, 1462-1480.

Maia, M.F.S., Caregnato, S.E. (2008). Co-autoria como indicador de redes de colaboração científica. *Perspectivas em Ciência da Informação*, 13(2), 18-31.

Melin, G., Persson O. (1996) Studing research using co-authorship. *Scientometrics,* 36, 363-377

Milojevic, S. (2010). Modes of Collaboration in Modern Science: Beyond Power Laws and Preferential Attachment. *Journal of the American Society for Information Science and Technology,* 61(7), 1410-1423.

Moore, M.T., Griffin, B.W. (2006). Identification of factors that influence authorship name placement and decisions to collaborate in peer-reviewed, education-related publications. *Studies in Educational Evaluation*, 32, 125-135.

Morel, C.M., Serruya, J., Penna, G.O., Guimarães, R. (2009). Co-authorship Network Analysis: A Powerful Tool for Strategic Planning or Research, Development and Capacity Building Programs on Neglected Diseases. *Plos Neglected Tropical Diseases*, 3(8), e501.

Morlacchi, P., Wilkinson, I., Young, L. (2004). Social Networks of Researchers in Business To Business Marketing: A Case Study of the IMP Group 1984-199. *SPRU Electronic Working Paper Series,* 116, 1-40.

Mueller-Porthmann, T., Finke, I. (2004). SELaKT - Social Network Analysis as a Method for Expert Localisation and Sustainable Knowledge Transfer. *Journal of Universal computer Science,* 10(6), 691-701.

Nahapiet, J., Ghoshal, S. (1998). Social Capital, Intellectual Capital, and the Organizational Advantage. *Academy of Management Review,* 23(2), 242-266.

Nascimento, M.A., Sander, J., Pound, J. (). Analysis of SIGMOD's Co-Authorship Graph. *ACM SIGMOD Record,* 32(3), 8-10.

Neto, M.C. et al. (2008). Social Network Analysis Applied to Knowledge Creation and Transfer in thePortuguese Agricultural R&D Field: an exploratory study. Harorima, D. &

Watkins, D. (2009). Proceedings of the 9th European Conference on Knowledge Management. Southampton, UK. ISBN:978-1-906638-10-8

Neto, M.C. and Fernandes, C. (2010). Enterprise Content Management Systems Potential to Support Human Capital Management Initiatives, International Journal of Engineering and Industrial Management, Nr.2 2010, pp. 75-92.

Neto, M., Fernandes, C., Ferreira, A. S., & Fernandes, L. M. (2010). Enterprise Information Portals: potential for evaluating research for Knowledge Management and Human Capital Assets using Social Network Analysis. In Tomé, E. (Ed.). Proceedings of the 11th European Conference on Knowledge Management (vol. 2, pp. 724-734), Reading: Academic Publishing.

Neto, M. C., Fernandes, C., & Fernandes, L. M. (2011, 11 - 14 July). Supporting Knowledge Management Initiatives in Research Institutions Using Social Network Analysis on Enterprise Content Management Systems Data Repositories. Paper presented at the 8th European Federation for Information Technology in Agriculture, Food and the Environment / 8th World Congress on Computers in Agriculture, Prague, Czech Republic.

Newman, M.E.J. (2001). Scientific collaboration networks. I. Network construction and fundamental results. *Physical Review E,* 64(016131), 1-8.

Newman, M.E.J. (2001). Scientific collaboration networks. II. Shortest paths, weighted networks, and centrality. *Physical Review E,* 64(016132), 1-7.

Newman, M.E.J. (2004). Coauthorship networks and patterns of scientific collaboration. *PNAS,* 101(1), 5200-5205.

OECD. (2002). *Frascati Manual. Proposed Standard Practice for Surveys on Research and Experimental Development.* Paris: OECD.

OECD. (2005). *Innovation in Fuel Cells: A Bibliometric Analysis.* Paris: OECD.

Oh, W., Choi, J.N., Kim, K. (2005). Coauthorship Dynamics and Knowledge Capital: The Patterns of Cross-Disciplinary Collaboration in Information Systems Research. *Journal of Management Information Systems,* 22(3), 265-292.

Okamura, K., Vonortas, N.S. (2006). European Allaince and Knowledge Networks. *Technology Analysis & Strategic Management,* 18(5), 535-560.

Olmeda-Gómez, C., Perianes-Rodriguez, A., Ovalle-Perandones, M.A., Guerrero-Bote, V.P., Anegón, F.M. (2008). Visualization of scientific co-authorship in Spanish universities - From regionalization to internationalization. *Aslib Proceedings: New Information Perspective,* 61(1), 83-100.

Ortega, J.L., Aguillo, I. (2009). Análisis structural de la web académica iberoamericana. *Revista Española de Documentación Científica,* 32(3), 29-65.

Pao, M.L. (1980) Co-authorship as a communicative measure. Library Research, 2, 237-338

Pao, M.L. (1980) Co-authorship and productivity. Proceedings of the American Society for Information Sciences 17, 279-289.

Piette, M.J., Ross, K.L. (1992). A Study of the Publication of Scholarly Output in Economics Journals. *Eastern Economic Journal,* 18(4), 429-436.

Racherla, P., Hu, C. (2010). A Social Network Perspective of Tourism Research Collaborations. *Annal of Tourism Research,* 37(4), 2023-1034.

Reagans, R., McEvily, B. (2003). Network Structure and Knowledge Transfer: The Effects of Cohesion and Range. *Administrative Science Quarterly,* 48, 240-267.

Said., Y.H., Wegman, E., Sharabati, W., Rigsby, J. (2008). Social networks of author-coauthor relationships. *Computational Statistics & Data Analysis,* 52, 2177-2184.

Schubert, A., Glänzel, W. (2006). Cross-national preference in co-authorship, references and citations. *Scientometrics,* 69(2), 409-428.

Smith, G. (2008). Mapping Social Networks among Crystallographers in South Africa. *The Electronic Journal of Knowledge Management,* 6(2), 157-166.

Subramanyam, K. (1983), Bibliometric studies of research collaboration: A review, *Journal of Information Science*

Sun, Y., Negishi, M. (2010). Measuring the relationships among university, industry and other sectors in Japan's national innovation system: a comparison of new approaches with mutual information indicators. *Scientometrics,* 82, 677-685.

Tonta, Y., Darvish, H.R. (2010). Diffusion of latent semantic analysis as a research tool: A social network analysis approach. *Journal of Informetrics,* 4, 166-174.

Trujillo, H.M., Mañas, F., González-Cabrera, J. (2009). Evaluación de la potencia explicativa de los grafos de redes sociales clandestinas con UciNet y NetDraw. *Universitas Psychologica,* 9(1), 67-78.

Tsai, W. (2002). Social Structure of "Coopetition" Within a Multiunit Organization: Coordination, Competition, and Intraorganizational Knowledge Sharing. *Organization Science,* 13(2), 179-190.

Valk, T., Gijsbers, G. (2010). The use of social network analysis in innovation studies: Mapping actors and technologies. *Innovation: management, policy & practice,* 15, 5-17.

Vidgen, R., Henneberg, S., Naudé, P. (2007). What sort of community is the European Conference on Information Systems? A social network analysis 1993-2005. *European Journal of Information Systems,* 16, 5-19.

Wellman, B. (1983). Network Analysis: Some Basic Principles. *Sociological Theory,* 1, 155-200.

Yan, E., Ding, Y. (2009). Applying Centrality Measures to Impact Analysis: A Coauthorship Network Analysis. *Journal of the American Society for Information Science and Technology,* 60, 2107-2118.

Yoshikane, F., Nozawa, T., Tsuji, K. (2006). Comparative analysis of co-authorship networks considering authors' roles in collaboration: Differences between the theoretical and application areas. *Scientometrics,* 68(3), 643-655.

Appendices

Appendix A – Software for Social Network Analysis

Table Overview of selected programs for social network analysis, with the number of the version that was reviewed, their objectives, data format (type, input format, missing values), functionality (visualization techniques, analysis methods), and support (availability of the program, manual, and online help). (Huysman et al., 2003)

				Data			Functionality		Support		
	Program	Ver.	Objective	Type[1]	Input[2]	Miss.	Visual.	Analyses[3]	Avail.[4]	Manual	Help
	Agna	2.0.7	general	c	m	no	yes	d, sl, sequential	free	yes	yes
	Blanche	4.6.4	network dynamics	c	m	no	yes	simulation	free	yes	yes
	FATCAT	4.2[5]	contextual analysis	c	ln	yes	no	d, s	free[5]	no	yes
	GRADAP	2.0[5]	graph analysis	c	ln	yes	no	d, sl, dt	com[5]	yes	no
	Iknow	–	knowledge networks	e	n	–	yes	d, sl	free	yes	yes
	InFlow	3.0	network mapping	c, e	ln	no	yes	d, sl, rp	com	yes	yes
	KliqFinder	0.05	cohesive subgroups	c	m, ln	no	yes	sl, s	–	yes	no
*	MultiNet	4.24	contextual analysis	c, l	ln	yes	yes[8]	d, rp, s	free	no[11]	yes
	NEGOPY	4.30[5]	cohesive subgroups	c	ln	yes	yes	d, sl, rp	com[5]	yes	yes
	NetDraw	1.0	visualization	c, e, a	m, ln	yes	yes	d, sl	free	yes	no
*	NetMiner II	2.3.0	visual analysis	c, e, a	m, ln	no	yes	d, sl, rp, dt, s	com[9,10]	yes	yes
	NetVis	2.0	visual exploration[6]	c, e, a	m, ln	no	yes	d, sl	free[6,9]	no	yes
*	Pajek	0.94	large data visualization	c, a, l	m, ln	yes[7]	yes	d, sl, rp, dt	free	no	no
	PermNet	0.94	permutation tests	c	m	yes	no	dt,s	free	no	yes
	PGRAPH	2.7	kinship networks	c	ln	–	no	d, rp	free	no[12]	yes
	ReferralWeb	2.0	referral chains	e	ln	–	yes	d	–[9]	yes	yes
	SM LinkAlyzer	2.1	hidden populations	e	ln	–	yes	d	com[10]	yes	yes
	SNAFU	2.0	general for MacOS[6]	c	m, ln	no	yes	d, sl	free	no	no
	Snowball	–[5]	hidden populations	e	ln	–	no	s	free[5]	yes	no
*	StOCNET	1.4	statistical analysis	c	m	yes	no	d, dt, s	free	yes	yes
*	STRUCTURE	4.2[5]	structural analysis	c, a	m	yes[7]	no	sl, rp	free[5]	yes	no
*	UCINET	6.05	comprehensive	c, e, a	m, ln	yes	yes[8]	d, sl, rp, dt, s	com[10]	yes	yes
	visone	1.0b1	visual exploration	c, e	m, ln	no	yes	d, sl	free	no	no

[1] c=complete, e=ego-centered, a=affiliation, l=large networks. [2] m=matrix, ln=link/node, n=node.
[3] d=descriptive, sl=structure and location, rp=roles and positions, dt=dyadic and triadic methods, s=statistical.
[4] com=commercial product, free=freeware/shareware. [5] DOS-program which is no longer updated.
[6] Open source software. [7] Only missing value codes for attributes.
[8] No graph drawing routines. [9] Freely accessible on the internet (some with reduced functionality).
[10] An evaluation/demonstration version is available. [11] The manual of some modules is available.
[12] The manual is available after registration.

Figure 16 - Software for Social Network Analysis

Appendix B – Exploratory Study

A.1. Bibliometric Analysis

Table I: Resource Types	#	%
Conference	424	26,3%
Journal Articles	1188	73,7%

Table 14: Exploratory Study: Resource Types (1995-2008)

Table II: Main Subjects Comparasion	#	%
Energy Sources	243	15,1%
Energy Production, Utilization, and Management	148	9,2%
Energy Conversion and Storage	20	1,2%
Basic information developed in support of energy	1201	74,5%

Table 15: Exploratory Study: Main Subjects (1995-2008)

Table III: Scientific Production per year	#	%
1995	92	5,7%
1996	79	4,9%
1997	71	4,4%
1998	74	4,6%
1999	90	5,6%
2000	96	6,0%
2001	85	5,3%
2002	130	8,1%
2003	162	10,0%
2004	194	12,0%
2005	141	8,7%
2006	184	11,4%
2007	157	9,7%
2008	57	3,5%

Table 16: Exploratory Study: Scientific production per year (1995-2008)

Table IV: Number of Authors per Resource	#	%
1	389	24,1%
2	397	24,6%
3	359	22,3%
4	198	12,3%
5	102	6,3%
6	59	3,7%
7	45	2,8%
8	23	1,4%
9	10	0,6%
>= 10	30	1,9%

Table 17: Exploratory Study: Number of authors per resource (1995-2008)

Table V: Average Number of Authors per Resource (Per year)	
1995	2,54
1996	2,24
1997	3,23
1998	2,76
1999	2,69
2000	2,67
2001	3,09
2002	2,91
2003	2,98
2004	3,46
2005	3,48
2006	3,46
2007	2,82
2008	3,33

Table 18: Exploratory Study: Average Number of Authors per resource per year

A.2. Social Network Analysis

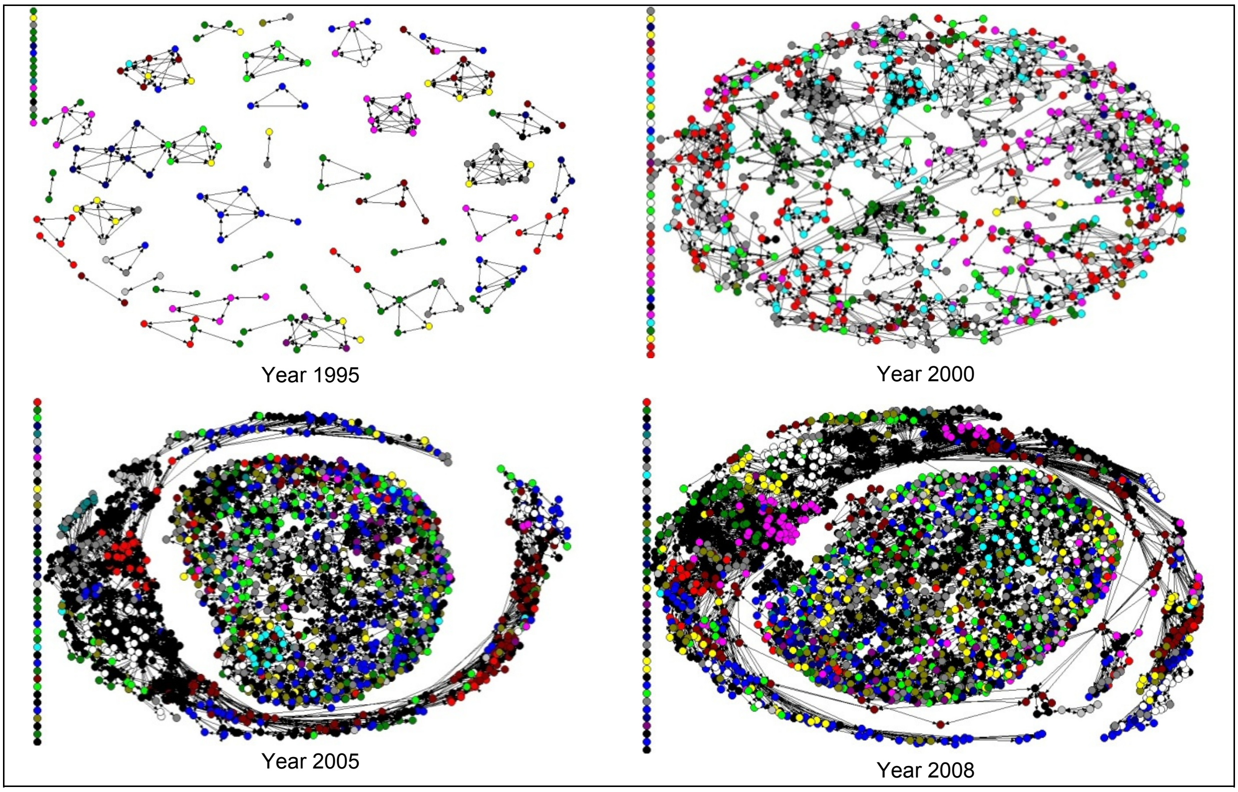


Figure 17: Exploratory Study: Energy field community co-authorship social network evolution (1995-2008)

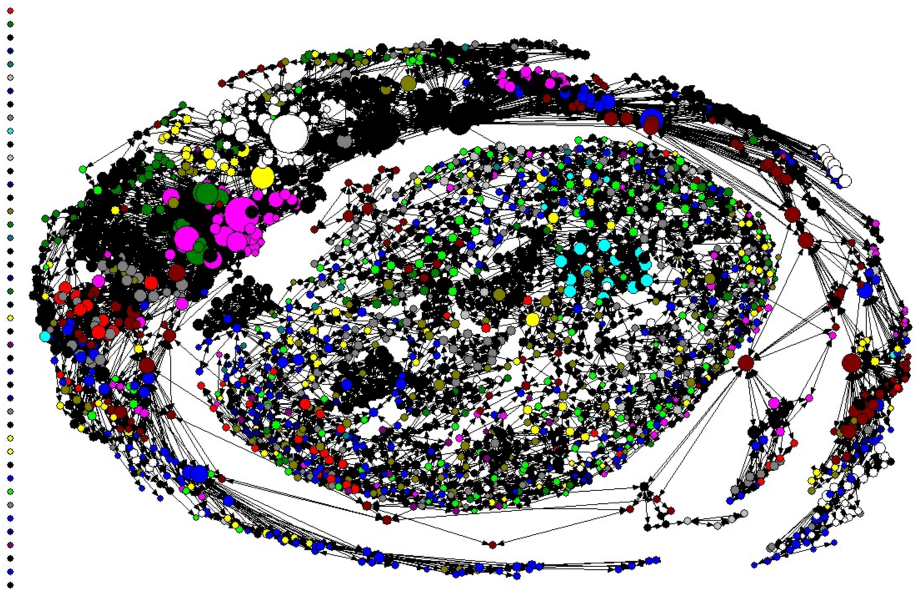
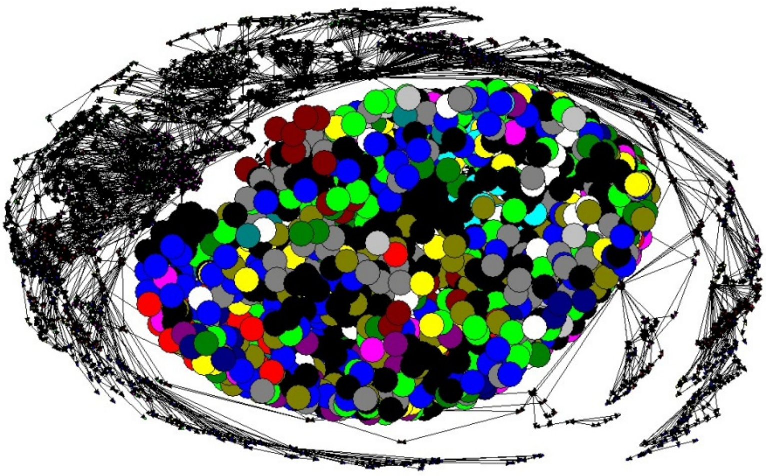


Figure 18: Exploratory Study: 2008 energy field community co-authorship social network evolution degree centrality



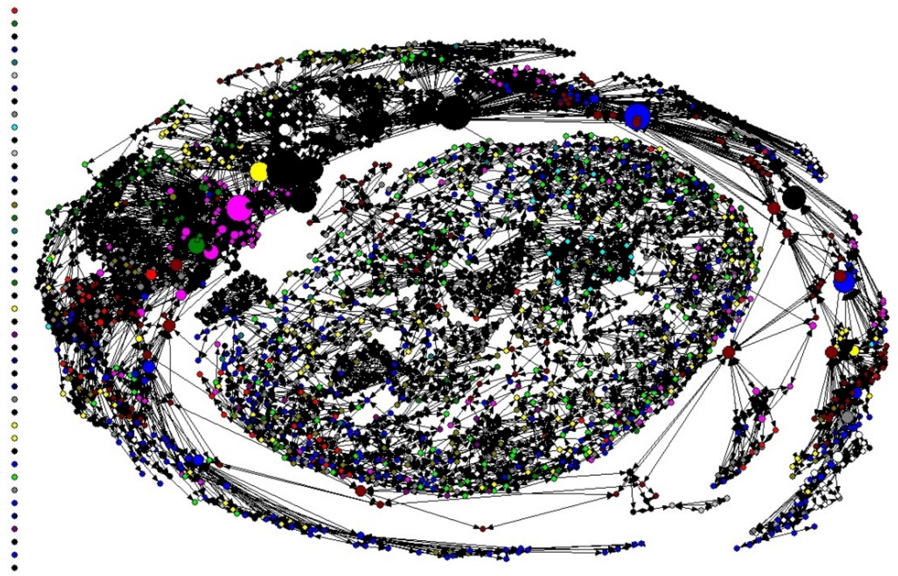


Figure 19: Exploratory Study: 2008 energy field community co-authorship social network evolution closeness centrality

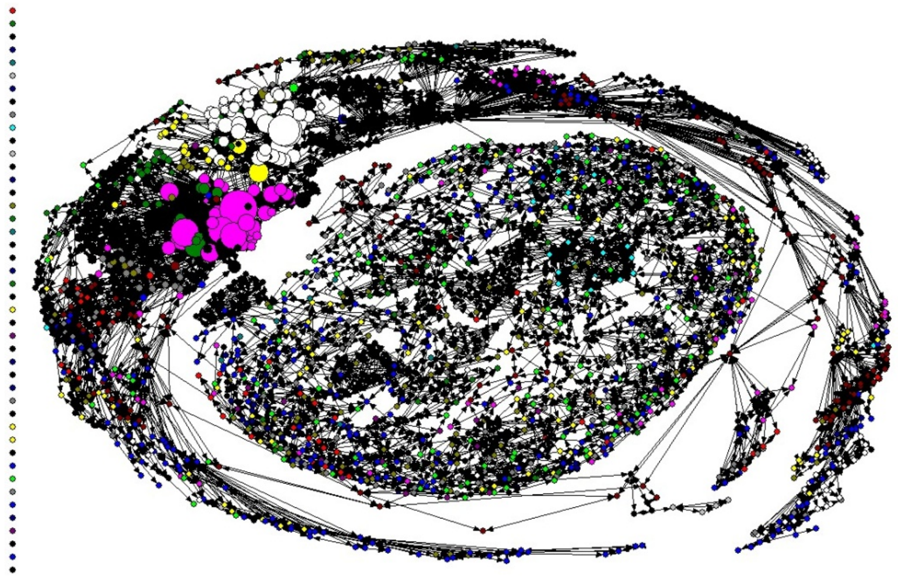


Figure 20: Exploratory Study: 2008 energy field community co-authorship social network evolution eigenvector centrality

Table VI: The authors with highest number of papers, degree, betweeness and eigenvector

Number of papers			Degree			Betwenness $(x10^4)$			Eigenvector		
81	Gulyurtlu, I	INETI	63	Gulyurtlu, I	INETI	17	Cupido, L.	Others	0,284	Varandas, C.A.F.	EURATOM/IST
74	Cabrita, I.	INETI	62	Alves, E.	Others	16	Fonseca, R.A.	Others	0,234	Gulyurtlu, I	INETI
35	Lemos, Jose P S	UTL	60	Cabrita, I.	INETI	11	Mendonca, J.T.	UTL	0,229	Cabrita, I.	INETI
30	Pinto, F.	INETI	57	Varandas, C.A.F.	EURATOM/IST	11	Cruz, N.	Others	0,209	Malaquias, A.	Others
30	Mendonca, J.T.	UTL	41	Malaquias, A.	Others	11	Varandas, C.A.F.	EURATOM/IST	0,195	Silva, C.	EURATOM/IST
28	Varandas, C.A.F.	EURATOM/IST	38	Silva, C.	EURATOM/IST	10	Carvalho, P.	Others	0,190	Cabral, J.A.C.	EURATOM/IST
25	Abelha, P.	INETI	37	Fonseca, R.A.	Others	10	Alves, E.	Others	0,178	Fernandes, H.	EURATOM/IST
25	Carvalho, M.G.	UTL	37	Freitas, P.P.	Others	9	Cardoso, V.	Others	0,153	Boavida, D.	INETI
24	Freitas, M.C	ITN	36	Barradas, N.P.	Others	8	Lemos, Jose P S	UTL	0,151	Nedzelskiy, I.	EURATOM/IST
23	Bicudo, P.	UTL	35	Mendonca, J.T.	UTL	8	Pereira, R.	DRAM - DIAS	0,144	Pereira, L.	UTL

Table 19: Exploratory Study: The authors with highest number of papers, degree, betweeness and eigenvector

Appendix C – Statistical Analysis per year

C.1. - Year 1995

Scientific Production per resource type	#	%
Conference	92	37.9%
Journal Articles	151	62.1%
Total	**243**	**100.0%**

Table 20: Scientific production per resource type - 1995

Main Subjects Distribution	#	%
Energy Sources	31	12.8%
Energy Production, Utilization, and Management	32	13.2%
Energy Conversion and Storage	1	0.4%
Basic information developed in support of energy	179	73.7%
Total	**243**	**100.0%**

Table 21: Total scientific production per main subject -1995

Number of Authors per Resource	#	%
1	24	9.9%
2	51	21.0%
3	79	32.5%
4	39	16.0%
5	19	7.8%
6	13	5.3%
7	5	2.1%
8	4	1.6%
9	1	0.4%
>= 10	8	3.3%

Table 22: Number of Authors per resource - 1995

Subjects Category Distribution	#	%
Coal, Lignite and Peat (01) [1]	18	7.4%
Petroleum (02) [1]	1	0.4%
Natural Gas (03) [1]	0	0.0%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	1	0.4%
Hydrogen (08) [3]	0	0.0%
Biomass Fuels (09) [1]	1	1.2%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	0	0.0%
Hydro Energy (13) [1]	1	0.4%
Solar Energy (14) [1]	1	0.4%
Geothermal Energy (15) [1]	0	0.0%
Tidal and Wave Power (16) [1]	5	2.1%
Wind Energy (17) [1]	1	0.4%
Fossil-Fuelled Power Plants (20) [2]	6	2.5%
Specific Nuclear Reactors and Associated Plants (21) [2]	0	0.0%
General Studies of Nuclear Reactors (22) [2]	2	0.8%
Power Transmission and Distribution (24) [2]	17	7.0%
Energy Storage (25) [2]	1	0.4%
Energy Planning, Policy, and Economy (29) [2]	1	0.4%
Direct Energy Conversion (30) [2]	0	0.0%
Energy Conservation, Consumption, and Utilization (32) [2]	6	2.5%
Advanced Propulsion Systems (33) [4]	0	0.0%
Materials Science (36) [4]	37	15.2%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	0	0.0%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	0	0.0%
Chemistry (40) [4]	16	6.6%
Engineering (42) [4]	11	4.5%
Particle Accelerators (43) [4]	0	0.0%
Instrumentation (44) [4]	17	7.0%
Military Technology (45) [4]	0	0.0%
Instrumentation Related to Nuclear Science and Technology (46) [4]	0	0.0%
Other Instrumentation (47) [4]	0	0.0%
Environmental Sciences (54) [4]	12	4.9%
Biology and Medicine (55) [4]	8	3.3%
Biology and Medicine (56) [4]	6	2.5%
Geosciences (58) [4]	0	0.0%
Applied Life Sciences (60) [4]	0	0.0%
Radiation Protection and Dosimetry (61) [4]	0	0.0%
Radiology and Nuclear Medicine (62) [4]	0	0.0%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63) [4]	0	0.0%
Physics (66) [4]	52	21.4%
Plasma Physics and Fusion Technology (70) [4]	11	4.5%
Classical and Quantum Mechanics, General Physics (71) [4]	1	0.4%
Physics of Elementary Particles and Fields (72) [4]	3	1.2%
Nuclear Physics and Radiation Physics (73) [4]	1	0.4%
Atomic and Molecular Physics (74) [4]	0	0.0%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	2	0.8%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	2	0.8%
Total	**243**	**100.0%**

Table 23: Subjects category distribution per subject order within the ETDEWEB – 1995

Subjects Category Distribution	**#**	**%**
Coal, Lignite and Peat (01) [1]	18	7.4%
Petroleum (02) [1]	1	0.4%
Natural Gas (03) [1]	0	0.0%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	1	0.4%
Hydrogen (08) [3]	0	0.0%
Biomass Fuels (09) [1]	1	1.2%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	0	0.0%
Hydro Energy (13) [1]	1	0.4%
Solar Energy (14) [1]	1	0.4%
Geothermal Energy (15) [1]	0	0.0%
Tidal and Wave Power (16) [1]	5	2.1%
Wind Energy (17) [1]	1	0.4%
Fossil-Fuelled Power Plants (20) [2]	6	2.5%
Specific Nuclear Reactors and Associated Plants (21) [2]	0	0.0%
General Studies of Nuclear Reactors (22) [2]	2	0.8%
Power Transmission and Distribution (24) [2]	17	7.0%
Energy Storage (25) [2]	1	0.4%
Energy Planning, Policy, and Economy (29) [2]	1	0.4%
Direct Energy Conversion (30) [2]	0	0.0%
Energy Conservation, Consumption, and Utilization (32) [2]	6	2.5%
Advanced Propulsion Systems (33) [4]	0	0.0%
Materials Science (36) [4]	37	15.2%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	0	0.0%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	0	0.0%
Chemistry (40) [4]	16	6.6%
Engineering (42) [4]	11	4.5%
Particle Accelerators (43) [4]	0	0.0%
Instrumentation (44) [4]	17	7.0%
Military Technology (45) [4]	0	0.0%
Instrumentation Related to Nuclear Science and Technology (46) [4]	0	0.0%
Other Instrumentation (47) [4]	0	0.0%
Environmental Sciences (54) [4]	12	4.9%
Biology and Medicine (55) [4]	8	3.3%
Biology and Medicine (56) [4]	6	2.5%
Geosciences (58) [4]	0	0.0%
Applied Life Sciences (60) [4]	0	0.0%
Radiation Protection and Dosimetry (61) [4]	0	0.0%
Radiology and Nuclear Medicine (62) [4]	0	0.0%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63) [4]	0	0.0%
Physics (66) [4]	52	21.4%
Plasma Physics and Fusion Technology (70) [4]	11	4.5%
Classical and Quantum Mechanics, General Physics (71) [4]	1	0.4%
Physics of Elementary Particles and Fields (72) [4]	3	1.2%
Nuclear Physics and Radiation Physics (73) [4]	1	0.4%
Atomic and Molecular Physics (74) [4]	0	0.0%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	2	0.8%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	2	0.8%
Total	**243**	**100.0%**

Table 24: Subjects category distribution sorted per number of publications - 1995

C.2. - Year 1996

Scientific Production per resource type	#	%
Conference	55	22.2%
Journal Articles	193	77.8%
Total	**248**	**100.0%**

Table 25: Scientific production per resource type –1996

Main Subjects Distribution	#	%
Energy Sources	31	12.5%
Energy Production, Utilization, and Management	19	7.7%
Energy Conversion and Storage	6	2.4%
Basic information developed in support of energy	192	77.4%
Total	**248**	**100.0%**

Table 26: Total scientific production per main subject -1996

Number of Authors per Resource	#	%
1	27	10.9%
2	42	16.9%
3	78	31.5%
4	35	14.1%
5	20	8.1%
6	17	6.9%
7	10	4.0%
8	6	2.4%
9	5	2.0%
>= 10	8	3.2%

Table 27: Number of Authors per resource - 1996

Subjects Category Distribution	#	%
Coal, Lignite and Peat (01) [1]	3	1.2%
Petroleum (02) [1]	7	2.8%
Natural Gas (03) [1]	0	0.0%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	2	0.8%
Hydrogen (08) [3]	0	0.0%
Biomass Fuels (09) [1]	6	2.4%
Synthetic Fuels (10) [3]	4	1.6%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	0	0.0%
Hydro Energy (13) [1]	0	0.0%
Solar Energy (14) [1]	6	2.4%
Geothermal Energy (15) [1]	3	1.2%
Tidal and Wave Power (16) [1]	4	1.6%
Wind Energy (17) [1]	0	0.0%
Fossil-Fuelled Power Plants (20) [2]	1	0.4%
Specific Nuclear Reactors and Associated Plants (21) [2]	0	0.0%
General Studies of Nuclear Reactors (22) [2]	2	0.8%
Power Transmission and Distribution (24) [2]	7	2.8%
Energy Storage (25) [2]	0	0.0%
Energy Planning, Policy, and Economy (29) [2]	2	0.8%
Direct Energy Conversion (30) [2]	2	0.8%
Energy Conservation, Consumption, and Utilization (32) [2]	7	2.8%
Advanced Propulsion Systems (33) [4]	0	0.0%
Materials Science (36) [4]	37	14.9%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	0	0.0%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	0	0.0%
Chemistry (40) [4]	14	5.6%
Engineering (42) [4]	11	4.4%
Particle Accelerators (43) [4]	2	0.8%
Instrumentation (44) [4]	32	12.9%
Military Technology (45) [4]	1	0.4%
Instrumentation Related to Nuclear Science and Technology (46) [4]	1	0.4%
Other Instrumentation (47) [4]	0	0.0%
Environmental Sciences (54) [4]	9	3.6%
Biology and Medicine (55) [4]	5	2.0%
Biology and Medicine (56) [4]	5	2.0%
Geosciences (58) [4]	0	0.0%
Applied Life Sciences (60) [4]	1	0.4%
Radiation Protection and Dosimetry (61) [4]	0	0.0%
Radiology and Nuclear Medicine (62) [4]	1	0.4%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63)	1	0.4%
Physics (66) [4]	48	19.4%
Plasma Physics and Fusion Technology (70) [4]	13	5.2%
Classical and Quantum Mechanics, General Physics (71) [4]	0	0.0%
Physics of Elementary Particles and Fields (72) [4]	1	0.4%
Nuclear Physics and Radiation Physics (73) [4]	0	0.0%
Atomic and Molecular Physics (74) [4]	0	0.0%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	3	1.2%
Nanoscience and Nanotechnology (77)[4]	7	2.8%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	0	0.0%
Total	**248**	**100.0%**

Table 28: Subjects category distribution per subject order within the ETDEWEB – 1996

Subjects Category Distribution sorted	#	%
Physics (66) [4]	48	19.4%
Materials Science (36) [4]	37	14.9%
Instrumentation (44) [4]	32	12.9%
Chemistry (40) [4]	14	5.6%
Plasma Physics and Fusion Technology (70) [4]	13	5.2%
Engineering (42) [4]	11	4.4%
Environmental Sciences (54) [4]	9	3.6%
Petroleum (02) [1]	7	2.8%
Power Transmission and Distribution (24) [2]	7	2.8%
Energy Conservation, Consumption, and Utilization (32) [2]	7	2.8%
Nanoscience and Nanotechnology (77)[4]	7	2.8%
Biomass Fuels (09) [1]	6	2.4%
Solar Energy (14) [1]	6	2.4%
Biology and Medicine (55) [4]	5	2.0%
Biology and Medicine (56) [4]	5	2.0%
Synthetic Fuels (10) [3]	4	1.6%
Tidal and Wave Power (16) [1]	4	1.6%
Coal, Lignite and Peat (01) [1]	3	1.2%
Geothermal Energy (15) [1]	3	1.2%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	3	1.2%
Isotopes and Radiation Sources (07) [1]	2	0.8%
General Studies of Nuclear Reactors (22) [2]	2	0.8%
Energy Planning, Policy, and Economy (29) [2]	2	0.8%
Direct Energy Conversion (30) [2]	2	0.8%
Particle Accelerators (43) [4]	2	0.8%
Fossil-Fuelled Power Plants (20) [2]	1	0.4%
Military Technology (45) [4]	1	0.4%
Instrumentation Related to Nuclear Science and Technology (46) [4]	1	0.4%
Applied Life Sciences (60) [4]	1	0.4%
Radiology and Nuclear Medicine (62) [4]	1	0.4%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63) [4]	1	0.4%
Physics of Elementary Particles and Fields (72) [4]	1	0.4%
Natural Gas (03) [1]	0	0.0%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Hydrogen (08) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	0	0.0%
Hydro Energy (13) [1]	0	0.0%
Wind Energy (17) [1]	0	0.0%
Specific Nuclear Reactors and Associated Plants (21) [2]	0	0.0%
Energy Storage (25) [2]	0	0.0%
Advanced Propulsion Systems (33) [4]	0	0.0%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	0	0.0%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	0	0.0%
Other Instrumentation (47) [4]	0	0.0%
Geosciences (58) [4]	0	0.0%
Radiation Protection and Dosimetry (61) [4]	0	0.0%
Classical and Quantum Mechanics, General Physics (71) [4]	0	0.0%
Nuclear Physics and Radiation Physics (73) [4]	0	0.0%
Atomic and Molecular Physics (74) [4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	0	0.0%
Total	**248**	**100%**

Table 29: Subjects category distribution sorted per number of publications - 1996

C.3. - Year 1997

Scientific Production per resource type	#	%
Conference	43	19.6%
Journal Articles	176	80.4%
Total	**219**	**100.0%**

Table 30: Scientific production per resource type –1997

Main Subjects Distribution	#	%
Energy Sources	23	10.5%
Energy Production, Utilization, and Management	20	9.1%
Energy Conversion and Storage	3	1.4%
Basic information developed in support of energy	173	79.0%
Total	**219**	**100.0%**

Table 31: Total scientific production per main subject -1997

Number of Authors per Resource	#	%
1	16	7.3%
2	46	21.0%
3	60	27.4%
4	38	17.4%
5	20	9.1%
6	15	6.8%
7	7	3.2%
8	3	1.4%
9	5	2.3%
>= 10	9	4.1%

Table 32: Number of Authors per resource - 1997

Subjects Category Distribution	#	%
Coal, Lignite and Peat (01) [1]	3	1.4%
Petroleum (02) [1]	6	2.7%
Natural Gas (03) [1]	4	1.8%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	0	0.0%
Hydrogen (08) [3]	0	0.0%
Biomass Fuels (09) [1]	4	1.8%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	0	0.0%
Hydro Energy (13) [1]	0	0.0%
Solar Energy (14) [1]	2	0.9%
Geothermal Energy (15) [1]	1	0.5%
Tidal and Wave Power (16) [1]	2	0.9%
Wind Energy (17) [1]	1	0.5%
Fossil-Fuelled Power Plants (20) [2]	0	0.0%
Specific Nuclear Reactors and Associated Plants (21) [2]	0	0.0%
General Studies of Nuclear Reactors (22) [2]	2	0.9%
Power Transmission and Distribution (24) [2]	9	4.1%
Energy Storage (25) [2]	1	0.5%
Energy Planning, Policy, and Economy (29) [2]	3	1.4%
Direct Energy Conversion (30) [2]	2	0.9%
Energy Conservation, Consumption, and Utilization (32) [2]	6	2.7%
Advanced Propulsion Systems (33) [4]	1	0.5%
Materials Science (36) [4]	48	21.9%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	0	0.0%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	0	0.0%
Chemistry (40) [4]	12	5.5%
Engineering (42) [4]	4	1.8%
Particle Accelerators (43) [4]	1	0.5%
Instrumentation (44) [4]	14	6.4%
Military Technology (45) [4]	0	0.0%
Instrumentation Related to Nuclear Science and Technology (46) [4]	0	0.0%
Other Instrumentation (47) [4]	0	0.0%
Environmental Sciences (54) [4]	13	5.9%
Biology and Medicine (55) [4]	3	1.4%
Biology and Medicine (56) [4]	3	1.4%
Geosciences (58) [4]	0	0.0%
Applied Life Sciences (60) [4]	0	0.0%
Radiation Protection and Dosimetry (61) [4]	0	0.0%
Radiology and Nuclear Medicine (62) [4]	5	2.3%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63)	0	0.0%
Physics (66) [4]	40	18.3%
Plasma Physics and Fusion Technology (70) [4]	21	9.6%
Classical and Quantum Mechanics, General Physics (71) [4]	2	0.9%
Physics of Elementary Particles and Fields (72) [4]	0	0.0%
Nuclear Physics and Radiation Physics (73) [4]	0	0.0%
Atomic and Molecular Physics (74) [4]	0	0.0%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	3	1.4%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	3	1.4%
Total	**219**	**100.0%**

Table 33: Subjects category distribution per subject order within the ETDEWEB – 1997

Subjects Category Distribution sorted	#	%
Materials Science (36) [4]	48	21.9%
Physics (66) [4]	40	18.3%
Plasma Physics and Fusion Technology (70) [4]	21	9.6%
Instrumentation (44) [4]	14	6.4%
Environmental Sciences (54) [4]	13	5.9%
Chemistry (40) [4]	12	5.5%
Power Transmission and Distribution (24) [2]	9	4.1%
Petroleum (02) [1]	6	2.7%
Energy Conservation, Consumption, and Utilization (32) [2]	6	2.7%
Radiology and Nuclear Medicine (62) [4]	5	2.3%
Natural Gas (03) [1]	4	1.8%
Biomass Fuels (09) [1]	4	1.8%
Engineering (42) [4]	4	1.8%
Coal, Lignite and Peat (01) [1]	3	1.4%
Energy Planning, Policy, and Economy (29) [2]	3	1.4%
Biology and Medicine (55) [4]	3	1.4%
Biology and Medicine (56) [4]	3	1.4%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	3	1.4%
General and Miscellaneous (99) [4]	3	1.4%
Solar Energy (14) [1]	2	0.9%
Tidal and Wave Power (16) [1]	2	0.9%
General Studies of Nuclear Reactors (22) [2]	2	0.9%
Direct Energy Conversion (30) [2]	2	0.9%
Classical and Quantum Mechanics, General Physics (71) [4]	2	0.9%
Geothermal Energy (15) [1]	1	0.5%
Wind Energy (17) [1]	1	0.5%
Energy Storage (25) [2]	1	0.5%
Advanced Propulsion Systems (33) [4]	1	0.5%
Particle Accelerators (43) [4]	1	0.5%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	0	0.0%
Hydrogen (08) [3]	0	0.0%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	0	0.0%
Hydro Energy (13) [1]	0	0.0%
Fossil-Fuelled Power Plants (20) [2]	0	0.0%
Specific Nuclear Reactors and Associated Plants (21) [2]	0	0.0%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	0	0.0%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Instrumentation Related to Nuclear Science and Technology (46) [4]	0	0.0%
Other Instrumentation (47) [4]	0	0.0%
Geosciences (58) [4]	0	0.0%
Applied Life Sciences (60) [4]	0	0.0%
Radiation Protection and Dosimetry (61) [4]	0	0.0%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63) [4]	0	0.0%
Physics of Elementary Particles and Fields (72) [4]	0	0.0%
Nuclear Physics and Radiation Physics (73) [4]	0	0.0%
Atomic and Molecular Physics (74) [4]	0	0.0%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
Total	**219**	**100.0%**

Table 34: Subjects category distribution sorted per number of publications - 1997

C.4. - Year 1998

Scientific Production per resource type	#	%
Conference	30	16.3%
Journal Articles	154	83.7%
Total	**184**	**100.0%**

Table 35: Scientific production per resource type –1998

Main Subjects Distribution	#	%
Energy Sources	19	10.3%
Energy Production, Utilization, and Management	11	6.0%
Energy Conversion and Storage	1	0.5%
Basic information developed in support of energy	153	83.2%
Total	**184**	**100.0%**

Table 36: Total scientific production per main subject -1998

Number of Authors per Resource	#	%
1	23	12.5%
2	30	16.3%
3	45	24.5%
4	27	14.7%
5	17	9.2%
6	9	4.9%
7	9	4.9%
8	6	3.3%
9	7	3.8%
>= 10	11	6.0%

Table 37: Number of Authors per resource - 1998

Subjects Category Distribution	#	%
Coal, Lignite and Peat (01) [1]	1	0.5%
Petroleum (02) [1]	2	1.1%
Natural Gas (03) [1]	2	1.1%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	2	1.1%
Hydrogen (08) [3]	0	0.0%
Biomass Fuels (09) [1]	4	2.2%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	0	0.0%
Hydro Energy (13) [1]	0	0.0%
Solar Energy (14) [1]	3	1.6%
Geothermal Energy (15) [1]	2	1.1%
Tidal and Wave Power (16) [1]	1	0.5%
Wind Energy (17) [1]	2	1.1%
Fossil-Fuelled Power Plants (20) [2]	2	1.1%
Specific Nuclear Reactors and Associated Plants (21) [2]	0	0.0%
General Studies of Nuclear Reactors (22) [2]	0	0.0%
Power Transmission and Distribution (24) [2]	0	0.0%
Energy Storage (25) [2]	1	0.5%
Energy Planning, Policy, and Economy (29) [2]	3	1.6%
Direct Energy Conversion (30) [2]	0	0.0%
Energy Conservation, Consumption, and Utilization (32) [2]	6	3.3%
Advanced Propulsion Systems (33) [4]	1	0.5%
Materials Science (36) [4]	40	21.7%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	0	0.0%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	1	0.5%
Chemistry (40) [4]	12	6.5%
Engineering (42) [4]	2	1.1%
Particle Accelerators (43) [4]	1	0.5%
Instrumentation (44) [4]	13	7.1%
Military Technology (45) [4]	0	0.0%
Instrumentation Related to Nuclear Science and Technology (46) [4]	4	2.2%
Other Instrumentation (47) [4]	0	0.0%
Environmental Sciences (54) [4]	6	3.3%
Biology and Medicine (55) [4]	9	4.9%
Biology and Medicine (56) [4]	2	1.1%
Geosciences (58) [4]	0	0.0%
Applied Life Sciences (60) [4]	0	0.0%
Radiation Protection and Dosimetry (61) [4]	2	1.1%
Radiology and Nuclear Medicine (62) [4]	4	2.2%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63)	2	1.1%
Physics (66) [4]	27	14.7%
Plasma Physics and Fusion Technology (70) [4]	14	7.6%
Classical and Quantum Mechanics, General Physics (71) [4]	1	0.5%
Physics of Elementary Particles and Fields (72) [4]	3	1.6%
Nuclear Physics and Radiation Physics (73) [4]	1	0.5%
Atomic and Molecular Physics (74) [4]	1	0.5%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	7	3.8%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	0	0.0%
Total	**184**	**100.0%**

Table 38: Subjects category distribution per subject order within the ETDEWEB – 1998

Subjects Category Distribution sorted	#	%
Materials Science (36) [4]	40	21.7%
Physics (66) [4]	27	14.7%
Plasma Physics and Fusion Technology (70) [4]	14	7.6%
Instrumentation (44) [4]	13	7.1%
Chemistry (40) [4]	12	6.5%
Biology and Medicine (55) [4]	9	4.9%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	7	3.8%
Energy Conservation, Consumption, and Utilization (32) [2]	6	3.3%
Environmental Sciences (54) [4]	6	3.3%
Biomass Fuels (09) [1]	4	2.2%
Instrumentation Related to Nuclear Science and Technology (46) [4]	4	2.2%
Radiology and Nuclear Medicine (62) [4]	4	2.2%
Solar Energy (14) [1]	3	1.6%
Energy Planning, Policy, and Economy (29) [2]	3	1.6%
Physics of Elementary Particles and Fields (72) [4]	3	1.6%
Petroleum (02) [1]	2	1.1%
Natural Gas (03) [1]	2	1.1%
Isotopes and Radiation Sources (07) [1]	2	1.1%
Geothermal Energy (15) [1]	2	1.1%
Wind Energy (17) [1]	2	1.1%
Fossil-Fuelled Power Plants (20) [2]	2	1.1%
Engineering (42) [4]	2	1.1%
Biology and Medicine (56) [4]	2	1.1%
Radiation Protection and Dosimetry (61) [4]	2	1.1%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63) [4]	2	1.1%
Coal, Lignite and Peat (01) [1]	1	0.5%
Tidal and Wave Power (16) [1]	1	0.5%
Energy Storage (25) [2]	1	0.5%
Advanced Propulsion Systems (33) [4]	1	0.5%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	1	0.5%
Particle Accelerators (43) [4]	1	0.5%
Classical and Quantum Mechanics, General Physics (71) [4]	1	0.5%
Nuclear Physics and Radiation Physics (73) [4]	1	0.5%
Atomic and Molecular Physics (74) [4]	1	0.5%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Hydrogen (08) [3]	0	0.0%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	0	0.0%
Hydro Energy (13) [1]	0	0.0%
Specific Nuclear Reactors and Associated Plants (21) [2]	0	0.0%
General Studies of Nuclear Reactors (22) [2]	0	0.0%
Power Transmission and Distribution (24) [2]	0	0.0%
Direct Energy Conversion (30) [2]	0	0.0%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Other Instrumentation (47) [4]	0	0.0%
Geosciences (58) [4]	0	0.0%
Applied Life Sciences (60) [4]	0	0.0%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	0	0.0%
Total	**184**	**100%**

Table 39: Subjects category distribution sorted per number of publications – 1998

C.5. - Year 1999

Scientific Production per resource type	#	%
Conference	77	35.5%
Journal Articles	140	64.5%
Total	**217**	**100.0%**

Table 40: Scientific production per resource type –1999

Main Subjects Distribution	#	%
Energy Sources	29	13.4%
Energy Production, Utilization, and Management	39	18.0%
Energy Conversion and Storage	1	0.5%
Basic information developed in support of energy	148	68.2%
Total	**217**	**100.0%**

Table 41: Total scientific production per main subject -1999

Number of Authors per Resource	#	%
1	27	12.4%
2	35	16.1%
3	54	24.9%
4	47	21.7%
5	20	9.2%
6	7	3.2%
7	6	2.8%
8	4	1.8%
9	6	2.8%
>= 10	11	5.1%

Table 42: Number of Authors per resource - 1999

Subjects Category Distribution	#	%
Coal, Lignite and Peat (01) [1]	8	3.7%
Petroleum (02) [1]	1	0.5%
Natural Gas (03) [1]	2	0.9%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	1	0.5%
Hydrogen (08) [3]	0	0.0%
Biomass Fuels (09) [1]	6	2.8%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	1	0.5%
Hydro Energy (13) [1]	0	0.0%
Solar Energy (14) [1]	3	1.4%
Geothermal Energy (15) [1]	0	0.0%
Tidal and Wave Power (16) [1]	2	0.9%
Wind Energy (17) [1]	6	2.8%
Fossil-Fuelled Power Plants (20) [2]	2	0.9%
Specific Nuclear Reactors and Associated Plants (21) [2]	0	0.0%
General Studies of Nuclear Reactors (22) [2]	2	0.9%
Power Transmission and Distribution (24) [2]	21	9.7%
Energy Storage (25) [2]	0	0.0%
Energy Planning, Policy, and Economy (29) [2]	5	2.3%
Direct Energy Conversion (30) [2]	1	0.5%
Energy Conservation, Consumption, and Utilization (32) [2]	8	3.7%
Advanced Propulsion Systems (33) [4]	0	0.0%
Materials Science (36) [4]	15	6.9%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	11	5.1%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	1	0.5%
Chemistry (40) [4]	4	1.8%
Engineering (42) [4]	9	4.1%
Particle Accelerators (43) [4]	0	0.0%
Instrumentation (44) [4]	5	2.3%
Military Technology (45) [4]	0	0.0%
Instrumentation Related to Nuclear Science and Technology (46) [4]	11	5.1%
Other Instrumentation (47) [4]	0	0.0%
Environmental Sciences (54) [4]	10	4.6%
Biology and Medicine (55) [4]	3	1.4%
Biology and Medicine (56) [4]	1	0.5%
Geosciences (58) [4]	2	0.9%
Applied Life Sciences (60) [4]	1	0.5%
Radiation Protection and Dosimetry (61) [4]	7	3.2%
Radiology and Nuclear Medicine (62) [4]	2	0.9%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63)	2	0.9%
Physics (66) [4]	12	5.5%
Plasma Physics and Fusion Technology (70) [4]	13	6.0%
Classical and Quantum Mechanics, General Physics (71) [4]	2	0.9%
Physics of Elementary Particles and Fields (72) [4]	18	8.3%
Nuclear Physics and Radiation Physics (73) [4]	7	3.2%
Atomic and Molecular Physics (74) [4]	0	0.0%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	12	5.5%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	0	0.0%
Total	**217**	**100.0%**

Table 43: Subjects category distribution per subject order within the ETDEWEB – 1999

Subjects Category Distribution sorted	#	%
Power Transmission and Distribution (24) [2	21	9.7%
Physics of Elementary Particles and Fields	18	8.3%
Materials Science (36) [4]	15	6.9%
Plasma Physics and Fusion Technology (70	13	6.0%
Physics (66) [4]	12	5.5%
Condensed Matter Physics, Superconductiv	12	5.5%
Inorganic, Organic, Physical and Analytical	11	5.1%
Instrumentation Related to Nuclear Science	11	5.1%
Environmental Sciences (54) [4]	10	4.6%
Engineering (42) [4]	9	4.1%
Coal, Lignite and Peat (01) [1]	8	3.7%
Energy Conservation, Consumption, and Util	8	3.7%
Radiation Protection and Dosimetry (61) [4]	7	3.2%
Nuclear Physics and Radiation Physics (73)	7	3.2%
Biomass Fuels (09) [1]	6	2.8%
Wind Energy (17) [1]	6	2.8%
Energy Planning, Policy, and Economy (29)	5	2.3%
Instrumentation (44) [4]	5	2.3%
Chemistry (40) [4]	4	1.8%
Solar Energy (14) [1]	3	1.4%
Biology and Medicine (55) [4]	3	1.4%
Natural Gas (03) [1]	2	0.9%
Tidal and Wave Power (16) [1]	2	0.9%
Fossil-Fuelled Power Plants (20) [2]	2	0.9%
General Studies of Nuclear Reactors (22) [2	2	0.9%
Geosciences (58) [4]	2	0.9%
Radiology and Nuclear Medicine (62) [4]	2	0.9%
Radiation, Thermal, and other Environmental	2	0.9%
Classical and Quantum Mechanics, General	2	0.9%
Petroleum (02) [1]	1	0.5%
Isotopes and Radiation Sources (07) [1]	1	0.5%
Management of Radioactive Wastes, and No	1	0.5%
Direct Energy Conversion (30) [2]	1	0.5%
Radiation Chemistry, Radiochemistry and N	1	0.5%
Biology and Medicine (56) [4]	1	0.5%
Applied Life Sciences (60) [4]	1	0.5%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Hydrogen (08) [3]	0	0.0%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [	0	0.0%
Hydro Energy (13) [1]	0	0.0%
Geothermal Energy (15) [1]	0	0.0%
Specific Nuclear Reactors and Associated F	0	0.0%
Energy Storage (25) [2]	0	0.0%
Advanced Propulsion Systems (33) [4]	0	0.0%
Particle Accelerators (43) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Other Instrumentation (47) [4]	0	0.0%
Atomic and Molecular Physics (74) [4]	0	0.0%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (7	0	0.0%
Knowledge Management and Preservation (9	0	0.0%
Mathematical Methods and Computing (97)[	0	0.0%
Nuclear Disarmament, Safeguards and Phys	0	0.0%
General and Miscellaneous (99) [4]	0	0.0%
Total	**217**	**100%**

Table 44: Subjects category distribution sorted per number of publications - 1999

C.6. - Year 2000

Scientific Production per resource type	#	%
Conference	115	40.9%
Journal Articles	166	59.1%
Total	**281**	**100.0%**

Table 45: Scientific production per resource type – 2000

Main Subjects Distribution	#	%
Energy Sources	23	8.2%
Energy Production, Utilization, and Management	35	12.5%
Energy Conversion and Storage	4	1.4%
Basic information developed in support of energy	219	77.9%
Total	**281**	**100.0%**

Table 46: Total scientific production per main subject - 2000

Number of Authors per Resource	#	%
1	27	9.6%
2	40	14.2%
3	87	31.0%
4	41	14.6%
5	23	8.2%
6	21	7.5%
7	12	4.3%
8	14	5.0%
9	7	2.5%
>= 10	9	3.2%

Table 47: Number of Authors per resource - 2000

Subjects Category Distribution	#	%
Coal, Lignite and Peat (01) [1]	1	0.4%
Petroleum (02) [1]	4	1.4%
Natural Gas (03) [1]	2	0.7%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	1	0.4%
Hydrogen (08) [3]	2	0.7%
Biomass Fuels (09) [1]	2	0.7%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	0	0.0%
Hydro Energy (13) [1]	2	0.7%
Solar Energy (14) [1]	8	2.8%
Geothermal Energy (15) [1]	2	0.7%
Tidal and Wave Power (16) [1]	0	0.0%
Wind Energy (17) [1]	1	0.4%
Fossil-Fuelled Power Plants (20) [2]	1	0.4%
Specific Nuclear Reactors and Associated Plants (21) [2]	9	3.2%
General Studies of Nuclear Reactors (22) [2]	2	0.7%
Power Transmission and Distribution (24) [2]	2	0.7%
Energy Storage (25) [2]	0	0.0%
Energy Planning, Policy, and Economy (29) [2]	5	1.8%
Direct Energy Conversion (30) [2]	2	0.7%
Energy Conservation, Consumption, and Utilization (32) [2]	16	5.7%
Advanced Propulsion Systems (33) [4]	1	0.4%
Materials Science (36) [4]	45	16.0%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	11	3.9%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	0	0.0%
Chemistry (40) [4]	0	0.0%
Engineering (42) [4]	13	4.6%
Particle Accelerators (43) [4]	0	0.0%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Instrumentation Related to Nuclear Science and Technology (46) [4]	4	1.4%
Other Instrumentation (47) [4]	0	0.0%
Environmental Sciences (54) [4]	18	6.4%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Geosciences (58) [4]	1	0.4%
Applied Life Sciences (60) [4]	3	1.1%
Radiation Protection and Dosimetry (61) [4]	9	3.2%
Radiology and Nuclear Medicine (62) [4]	10	3.6%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63)	1	0.4%
Physics (66) [4]	0	0.0%
Plasma Physics and Fusion Technology (70) [4]	32	11.4%
Classical and Quantum Mechanics, General Physics (71) [4]	3	1.1%
Physics of Elementary Particles and Fields (72) [4]	35	12.5%
Nuclear Physics and Radiation Physics (73) [4]	15	5.3%
Atomic and Molecular Physics (74) [4]	3	1.1%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	14	5.0%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	1	0.4%
Total	**281**	**100.0%**

Table 48: Subjects category distribution per subject order within the ETDEWEB – 2000

Subjects Category Distribution sorted	#	%
Materials Science (36) [4]	45	16.0%
Physics of Elementary Particles and Fields (72) [4]	35	12.5%
Plasma Physics and Fusion Technology (70) [4]	32	11.4%
Environmental Sciences (54) [4]	18	6.4%
Energy Conservation, Consumption, and Utilization (32) [2]	16	5.7%
Nuclear Physics and Radiation Physics (73) [4]	15	5.3%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	14	5.0%
Engineering (42) [4]	13	4.6%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	11	3.9%
Radiology and Nuclear Medicine (62) [4]	10	3.6%
Specific Nuclear Reactors and Associated Plants (21) [2]	9	3.2%
Radiation Protection and Dosimetry (61) [4]	9	3.2%
Solar Energy (14) [1]	8	2.8%
Energy Planning, Policy, and Economy (29) [2]	5	1.8%
Petroleum (02) [1]	4	1.4%
Instrumentation Related to Nuclear Science and Technology (46) [4]	4	1.4%
Applied Life Sciences (60) [4]	3	1.1%
Classical and Quantum Mechanics, General Physics (71) [4]	3	1.1%
Atomic and Molecular Physics (74) [4]	3	1.1%
Natural Gas (03) [1]	2	0.7%
Hydrogen (08) [3]	2	0.7%
Biomass Fuels (09) [1]	2	0.7%
Hydro Energy (13) [1]	2	0.7%
Geothermal Energy (15) [1]	2	0.7%
General Studies of Nuclear Reactors (22) [2]	2	0.7%
Power Transmission and Distribution (24) [2]	2	0.7%
Direct Energy Conversion (30) [2]	2	0.7%
Coal, Lignite and Peat (01) [1]	1	0.4%
Isotopes and Radiation Sources (07) [1]	1	0.4%
Wind Energy (17) [1]	1	0.4%
Fossil-Fuelled Power Plants (20) [2]	1	0.4%
Advanced Propulsion Systems (33) [4]	1	0.4%
Geosciences (58) [4]	1	0.4%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63) [4]	1	0.4%
General and Miscellaneous (99) [4]	1	0.4%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	0	0.0%
Tidal and Wave Power (16) [1]	0	0.0%
Energy Storage (25) [2]	0	0.0%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	0	0.0%
Chemistry (40) [4]	0	0.0%
Particle Accelerators (43) [4]	0	0.0%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Other Instrumentation (47) [4]	0	0.0%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Physics (66) [4]	0	0.0%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
Total	**281**	**100%**

Table 49: Subjects category distribution sorted per number of publications - 2000

C.7. - Year 2001

Scientific Production per resource type	#	%
Conference	92	37.4%
Journal Articles	154	62.6%
Total	**246**	**100.0%**

Table 50: Scientific production per resource type – 2001

Main Subjects Distribution	#	%
Energy Sources	28	11.4%
Energy Production, Utilization, and Management	17	6.9%
Energy Conversion and Storage	2	0.8%
Basic information developed in support of energy	199	80.9%
Total	**246**	**100.0%**

Table 51: Total scientific production per main subject - 2001

Number of Authors per Resource	#	%
1	23	9.3%
2	41	16.7%
3	62	25.2%
4	39	15.9%
5	35	14.2%
6	12	4.9%
7	9	3.7%
8	8	3.3%
9	4	1.6%
>= 10	13	5.3%

Table 52: Number of Authors per resource - 2001

Subjects Category Distribution	**#**	**%**
Coal, Lignite and Peat (01) [1]	6	2.4%
Petroleum (02) [1]	3	1.2%
Natural Gas (03) [1]	0	0.0%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	1	0.4%
Hydrogen (08) [3]	1	0.4%
Biomass Fuels (09) [1]	0	0.0%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	1	0.4%
Hydro Energy (13) [1]	0	0.0%
Solar Energy (14) [1]	5	2.0%
Geothermal Energy (15) [1]	0	0.0%
Tidal and Wave Power (16) [1]	12	4.9%
Wind Energy (17) [1]	1	0.4%
Fossil-Fuelled Power Plants (20) [2]	3	1.2%
Specific Nuclear Reactors and Associated Plants (21) [2]	1	0.4%
General Studies of Nuclear Reactors (22) [2]	0	0.0%
Power Transmission and Distribution (24) [2]	0	0.0%
Energy Storage (25) [2]	1	0.4%
Energy Planning, Policy, and Economy (29) [2]	3	1.2%
Direct Energy Conversion (30) [2]	0	0.0%
Energy Conservation, Consumption, and Utilization (32) [2]	9	3.7%
Advanced Propulsion Systems (33) [4]	0	0.0%
Materials Science (36) [4]	38	15.4%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	13	5.3%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	0	0.0%
Chemistry (40) [4]	0	0.0%
Engineering (42) [4]	3	1.2%
Particle Accelerators (43) [4]	4	1.6%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Instrumentation Related to Nuclear Science and Technology (46) [4]	3	1.2%
Other Instrumentation (47) [4]	4	1.6%
Environmental Sciences (54) [4]	12	4.9%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Geosciences (58) [4]	0	0.0%
Applied Life Sciences (60) [4]	1	0.4%
Radiation Protection and Dosimetry (61) [4]	9	3.7%
Radiology and Nuclear Medicine (62) [4]	5	2.0%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63)	1	0.4%
Physics (66) [4]	0	0.0%
Plasma Physics and Fusion Technology (70) [4]	26	10.6%
Classical and Quantum Mechanics, General Physics (71) [4]	11	4.5%
Physics of Elementary Particles and Fields (72) [4]	27	11.0%
Nuclear Physics and Radiation Physics (73) [4]	16	6.5%
Atomic and Molecular Physics (74) [4]	7	2.8%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	18	7.3%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	1	0.4%
Total	**246**	**100.0%**

Table 53: Subjects category distribution per subject order within the ETDEWEB – 2001

Subjects Category Distribution sorted	#	%
Materials Science (36) [4]	38	15.4%
Physics of Elementary Particles and Fields (72) [4]	27	11.0%
Plasma Physics and Fusion Technology (70) [4]	26	10.6%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	18	7.3%
Nuclear Physics and Radiation Physics (73) [4]	16	6.5%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	13	5.3%
Tidal and Wave Power (16) [1]	12	4.9%
Environmental Sciences (54) [4]	12	4.9%
Classical and Quantum Mechanics, General Physics (71) [4]	11	4.5%
Energy Conservation, Consumption, and Utilization (32) [2]	9	3.7%
Radiation Protection and Dosimetry (61) [4]	9	3.7%
Atomic and Molecular Physics (74) [4]	7	2.8%
Coal, Lignite and Peat (01) [1]	6	2.4%
Solar Energy (14) [1]	5	2.0%
Radiology and Nuclear Medicine (62) [4]	5	2.0%
Particle Accelerators (43) [4]	4	1.6%
Other Instrumentation (47) [4]	4	1.6%
Petroleum (02) [1]	3	1.2%
Fossil-Fuelled Power Plants (20) [2]	3	1.2%
Energy Planning, Policy, and Economy (29) [2]	3	1.2%
Engineering (42) [4]	3	1.2%
Instrumentation Related to Nuclear Science and Technology (46) [4]	3	1.2%
Isotopes and Radiation Sources (07) [1]	1	0.4%
Hydrogen (08) [3]	1	0.4%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	1	0.4%
Wind Energy (17) [1]	1	0.4%
Specific Nuclear Reactors and Associated Plants (21) [2]	1	0.4%
Energy Storage (25) [2]	1	0.4%
Applied Life Sciences (60) [4]	1	0.4%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63) [4]	1	0.4%
General and Miscellaneous (99) [4]	1	0.4%
Natural Gas (03) [1]	0	0.0%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Biomass Fuels (09) [1]	0	0.0%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Hydro Energy (13) [1]	0	0.0%
Geothermal Energy (15) [1]	0	0.0%
General Studies of Nuclear Reactors (22) [2]	0	0.0%
Power Transmission and Distribution (24) [2]	0	0.0%
Direct Energy Conversion (30) [2]	0	0.0%
Advanced Propulsion Systems (33) [4]	0	0.0%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	0	0.0%
Chemistry (40) [4]	0	0.0%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Geosciences (58) [4]	0	0.0%
Physics (66) [4]	0	0.0%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
Total	**246**	**100%**

Table 54: Subjects category distribution sorted per number of publications - 2001

C.8. - Year 2002

Scientific Production per resource type	#	%
Conference	54	17.6%
Journal Articles	252	82.4%
Total	**306**	**100.0%**

Table 55: Scientific production per resource type – 2002

Main Subjects Distribution	#	%
Energy Sources	25	8.2%
Energy Production, Utilization, and Management	9	2.9%
Energy Conversion and Storage	6	2.0%
Basic information developed in support of energy	266	86.9%
Total	**306**	**100.0%**

Table 56: Total scientific production per main subject – 2002

Number of Authors per Resource	#	%
1	26	8.5%
2	61	19.9%
3	73	23.9%
4	44	14.4%
5	32	10.5%
6	21	6.9%
7	17	5.6%
8	13	4.2%
9	6	2.0%
>= 10	13	4.2%

Table 57: Number of Authors per resource - 2002

Subjects Category Distribution	#	%
Coal, Lignite and Peat (01) [1]	5	1.6%
Petroleum (02) [1]	2	0.7%
Natural Gas (03) [1]	0	0.0%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	0	0.0%
Hydrogen (08) [3]	4	1.3%
Biomass Fuels (09) [1]	5	1.6%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	0	0.0%
Hydro Energy (13) [1]	0	0.0%
Solar Energy (14) [1]	0	0.0%
Geothermal Energy (15) [1]	5	1.6%
Tidal and Wave Power (16) [1]	7	2.3%
Wind Energy (17) [1]	1	0.3%
Fossil-Fuelled Power Plants (20) [2]	1	0.3%
Specific Nuclear Reactors and Associated Plants (21) [2]	0	0.0%
General Studies of Nuclear Reactors (22) [2]	0	0.0%
Power Transmission and Distribution (24) [2]	1	0.3%
Energy Storage (25) [2]	1	0.3%
Energy Planning, Policy, and Economy (29) [2]	3	1.0%
Direct Energy Conversion (30) [2]	1	0.3%
Energy Conservation, Consumption, and Utilization (32) [2]	4	1.3%
Advanced Propulsion Systems (33) [4]	0	0.0%
Materials Science (36) [4]	60	19.6%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	11	3.6%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	2	0.7%
Chemistry (40) [4]	0	0.0%
Engineering (42) [4]	11	3.6%
Particle Accelerators (43) [4]	0	0.0%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Instrumentation Related to Nuclear Science and Technology (46) [4]	4	1.3%
Other Instrumentation (47) [4]	0	0.0%
Environmental Sciences (54) [4]	4	1.3%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Geosciences (58) [4]	1	0.3%
Applied Life Sciences (60) [4]	1	0.3%
Radiation Protection and Dosimetry (61) [4]	5	1.6%
Radiology and Nuclear Medicine (62) [4]	11	3.6%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63)	2	0.7%
Physics (66) [4]	0	0.0%
Plasma Physics and Fusion Technology (70) [4]	32	10.5%
Classical and Quantum Mechanics, General Physics (71) [4]	17	5.6%
Physics of Elementary Particles and Fields (72) [4]	50	16.3%
Nuclear Physics and Radiation Physics (73) [4]	32	10.5%
Atomic and Molecular Physics (74) [4]	3	1.0%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	20	6.5%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	0	0.0%
Total	**306**	**100.0%**

Table 58: Subjects category distribution per subject order within the ETDEWEB – 2002

Subjects Category Distribution sorted	#	%
Materials Science (36) [4]	60	19.6%
Physics of Elementary Particles and Fields (72) [4]	50	16.3%
Plasma Physics and Fusion Technology (70) [4]	32	10.5%
Nuclear Physics and Radiation Physics (73) [4]	32	10.5%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	20	6.5%
Classical and Quantum Mechanics, General Physics (71) [4]	17	5.6%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	11	3.6%
Engineering (42) [4]	11	3.6%
Radiology and Nuclear Medicine (62) [4]	11	3.6%
Tidal and Wave Power (16) [1]	7	2.3%
Coal, Lignite and Peat (01) [1]	5	1.6%
Biomass Fuels (09) [1]	5	1.6%
Geothermal Energy (15) [1]	5	1.6%
Radiation Protection and Dosimetry (61) [4]	5	1.6%
Hydrogen (08) [3]	4	1.3%
Energy Conservation, Consumption, and Utilization (32) [2]	4	1.3%
Instrumentation Related to Nuclear Science and Technology (46) [4]	4	1.3%
Environmental Sciences (54) [4]	4	1.3%
Energy Planning, Policy, and Economy (29) [2]	3	1.0%
Atomic and Molecular Physics (74) [4]	3	1.0%
Petroleum (02) [1]	2	0.7%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	2	0.7%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63) [4]	2	0.7%
Wind Energy (17) [1]	1	0.3%
Fossil-Fuelled Power Plants (20) [2]	1	0.3%
Power Transmission and Distribution (24) [2]	1	0.3%
Energy Storage (25) [2]	1	0.3%
Direct Energy Conversion (30) [2]	1	0.3%
Geosciences (58) [4]	1	0.3%
Applied Life Sciences (60) [4]	1	0.3%
Natural Gas (03) [1]	0	0.0%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	0	0.0%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	0	0.0%
Hydro Energy (13) [1]	0	0.0%
Solar Energy (14) [1]	0	0.0%
Specific Nuclear Reactors and Associated Plants (21) [2]	0	0.0%
General Studies of Nuclear Reactors (22) [2]	0	0.0%
Advanced Propulsion Systems (33) [4]	0	0.0%
Chemistry (40) [4]	0	0.0%
Particle Accelerators (43) [4]	0	0.0%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Other Instrumentation (47) [4]	0	0.0%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Physics (66) [4]	0	0.0%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	0	0.0%
Total	**306**	**100%**

Table 59: Subjects category distribution sorted per number of publications - 2002

C.9. - Year 2003

Scientific Production per resource type	#	%
Conference	82	22.1%
Journal Articles	289	77.9%
Total	**371**	**100.0%**

Table 60: Scientific production per resource type – 2003

Main Subjects Distribution	#	%
Energy Sources	25	6.7%
Energy Production, Utilization, and Management	23	6.2%
Energy Conversion and Storage	1	0.3%
Basic information developed in support of energy	322	86.8%
Total	**371**	**100.0%**

Table 61: Total scientific production per main subject – 2003

Number of Authors per Resource	#	%
1	37	10.0%
2	72	19.4%
3	83	22.4%
4	55	14.8%
5	45	12.1%
6	21	5.7%
7	20	5.4%
8	10	2.7%
9	6	1.6%
>= 10	22	5.9%

Table 62: Number of Authors per resource - 2003

Subjects Category Distribution	#	%
Coal, Lignite and Peat (01) [1]	12	3.2%
Petroleum (02) [1]	1	0.3%
Natural Gas (03) [1]	0	0.0%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	0	0.0%
Hydrogen (08) [3]	0	0.0%
Biomass Fuels (09) [1]	5	1.3%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	1	0.3%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	0	0.0%
Hydro Energy (13) [1]	0	0.0%
Solar Energy (14) [1]	5	1.3%
Geothermal Energy (15) [1]	0	0.0%
Tidal and Wave Power (16) [1]	0	0.0%
Wind Energy (17) [1]	1	0.3%
Fossil-Fuelled Power Plants (20) [2]	1	0.3%
Specific Nuclear Reactors and Associated Plants (21) [2]	3	0.8%
General Studies of Nuclear Reactors (22) [2]	0	0.0%
Power Transmission and Distribution (24) [2]	1	0.3%
Energy Storage (25) [2]	0	0.0%
Energy Planning, Policy, and Economy (29) [2]	6	1.6%
Direct Energy Conversion (30) [2]	1	0.3%
Energy Conservation, Consumption, and Utilization (32) [2]	12	3.2%
Advanced Propulsion Systems (33) [4]	0	0.0%
Materials Science (36) [4]	32	8.6%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	9	2.4%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	1	0.3%
Chemistry (40) [4]	0	0.0%
Engineering (42) [4]	7	1.9%
Particle Accelerators (43) [4]	0	0.0%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Instrumentation Related to Nuclear Science and Technology (46) [4]	2	0.5%
Other Instrumentation (47) [4]	0	0.0%
Environmental Sciences (54) [4]	19	5.1%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Geosciences (58) [4]	1	0.3%
Applied Life Sciences (60) [4]	1	0.3%
Radiation Protection and Dosimetry (61) [4]	5	1.3%
Radiology and Nuclear Medicine (62) [4]	10	2.7%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63)	2	0.5%
Physics (66) [4]	0	0.0%
Plasma Physics and Fusion Technology (70) [4]	43	11.6%
Classical and Quantum Mechanics, General Physics (71) [4]	20	5.4%
Physics of Elementary Particles and Fields (72) [4]	103	27.8%
Nuclear Physics and Radiation Physics (73) [4]	31	8.4%
Atomic and Molecular Physics (74) [4]	13	3.5%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	23	6.2%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	0	0.0%
Total	**371**	**100.0%**

Table 63: Subjects category distribution per subject order within the ETDEWEB – 2003

Subjects Category Distribution sorted	#	%
Physics of Elementary Particles and Fields (72) [4]	103	27.8%
Plasma Physics and Fusion Technology (70) [4]	43	11.6%
Materials Science (36) [4]	32	8.6%
Nuclear Physics and Radiation Physics (73) [4]	31	8.4%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	23	6.2%
Classical and Quantum Mechanics, General Physics (71) [4]	20	5.4%
Environmental Sciences (54) [4]	19	5.1%
Atomic and Molecular Physics (74) [4]	13	3.5%
Coal, Lignite and Peat (01) [1]	12	3.2%
Energy Conservation, Consumption, and Utilization (32) [2]	12	3.2%
Radiology and Nuclear Medicine (62) [4]	10	2.7%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	9	2.4%
Engineering (42) [4]	7	1.9%
Energy Planning, Policy, and Economy (29) [2]	6	1.6%
Biomass Fuels (09) [1]	5	1.3%
Solar Energy (14) [1]	5	1.3%
Radiation Protection and Dosimetry (61) [4]	5	1.3%
Specific Nuclear Reactors and Associated Plants (21) [2]	3	0.8%
Instrumentation Related to Nuclear Science and Technology (46) [4]	2	0.5%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63) [4]	2	0.5%
Petroleum (02) [1]	1	0.3%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	1	0.3%
Wind Energy (17) [1]	1	0.3%
Fossil-Fuelled Power Plants (20) [2]	1	0.3%
Power Transmission and Distribution (24) [2]	1	0.3%
Direct Energy Conversion (30) [2]	1	0.3%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	1	0.3%
Geosciences (58) [4]	1	0.3%
Applied Life Sciences (60) [4]	1	0.3%
Natural Gas (03) [1]	0	0.0%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	0	0.0%
Hydrogen (08) [3]	0	0.0%
Synthetic Fuels (10) [3]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	0	0.0%
Hydro Energy (13) [1]	0	0.0%
Geothermal Energy (15) [1]	0	0.0%
Tidal and Wave Power (16) [1]	0	0.0%
General Studies of Nuclear Reactors (22) [2]	0	0.0%
Energy Storage (25) [2]	0	0.0%
Advanced Propulsion Systems (33) [4]	0	0.0%
Chemistry (40) [4]	0	0.0%
Particle Accelerators (43) [4]	0	0.0%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Other Instrumentation (47) [4]	0	0.0%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Physics (66) [4]	0	0.0%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	0	0.0%
Total	**371**	**100%**

Table 64: Subjects category distribution sorted per number of publications - 2003

C.10. - Year 2004

Scientific Production per resource type	#	%
Conference	75	15.3%
Journal Articles	416	84.7%
Total	**491**	**100.0%**

Table 65: Scientific production per resource type – 2004

Main Subjects Distribution	#	%
Energy Sources	28	5.7%
Energy Production, Utilization, and Management	13	2.6%
Energy Conversion and Storage	9	1.8%
Basic information developed in support of energy	441	89.8%
Total	**491**	**100.0%**

Table 66: Total scientific production per main subject – 2004

Number of Authors per Resource	#	%
1	53	10.8%
2	85	17.3%
3	112	22.8%
4	70	14.3%
5	63	12.8%
6	29	5.9%
7	26	5.3%
8	11	2.2%
9	10	2.0%
>= 10	32	6.5%

Table 67: Number of Authors per resource - 2004

Subjects Category Distribution	#	%
Coal, Lignite and Peat (01) [1]	10	2.0%
Petroleum (02) [1]	1	0.2%
Natural Gas (03) [1]	1	0.2%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	0	0.0%
Hydrogen (08) [3]	1	0.2%
Biomass Fuels (09) [1]	2	0.4%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	2	0.4%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	1	0.2%
Hydro Energy (13) [1]	0	0.0%
Solar Energy (14) [1]	7	1.4%
Geothermal Energy (15) [1]	0	0.0%
Tidal and Wave Power (16) [1]	5	1.0%
Wind Energy (17) [1]	0	0.0%
Fossil-Fuelled Power Plants (20) [2]	1	0.2%
Specific Nuclear Reactors and Associated Plants (21) [2]	0	0.0%
General Studies of Nuclear Reactors (22) [2]	0	0.0%
Power Transmission and Distribution (24) [2]	1	0.2%
Energy Storage (25) [2]	2	0.4%
Energy Planning, Policy, and Economy (29) [2]	7	1.4%
Direct Energy Conversion (30) [2]	6	1.2%
Energy Conservation, Consumption, and Utilization (32) [2]	3	0.6%
Advanced Propulsion Systems (33) [4]	0	0.0%
Materials Science (36) [4]	64	13.0%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	19	3.9%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	0	0.0%
Chemistry (40) [4]	0	0.0%
Engineering (42) [4]	9	1.8%
Particle Accelerators (43) [4]	2	0.4%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Instrumentation Related to Nuclear Science and Technology (46) [4]	17	3.5%
Other Instrumentation (47) [4]	1	0.2%
Environmental Sciences (54) [4]	23	4.7%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Geosciences (58) [4]	2	0.4%
Applied Life Sciences (60) [4]	1	0.2%
Radiation Protection and Dosimetry (61) [4]	7	1.4%
Radiology and Nuclear Medicine (62) [4]	4	0.8%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63)	0	0.0%
Physics (66) [4]	0	0.0%
Plasma Physics and Fusion Technology (70) [4]	69	14.1%
Classical and Quantum Mechanics, General Physics (71) [4]	39	7.9%
Physics of Elementary Particles and Fields (72) [4]	117	23.8%
Nuclear Physics and Radiation Physics (73) [4]	25	5.1%
Atomic and Molecular Physics (74) [4]	7	1.4%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	35	7.1%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	0	0.0%
Total	**491**	**100.0%**

Table 68: Subjects category distribution per subject order within the ETDEWEB – 2004

Subjects Category Distribution sorted	#	%
Physics of Elementary Particles and Fields (72) [4]	117	23.8%
Plasma Physics and Fusion Technology (70) [4]	69	14.1%
Materials Science (36) [4]	64	13.0%
Classical and Quantum Mechanics, General Physics (71) [4]	39	7.9%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	35	7.1%
Nuclear Physics and Radiation Physics (73) [4]	25	5.1%
Environmental Sciences (54) [4]	23	4.7%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	19	3.9%
Instrumentation Related to Nuclear Science and Technology (46) [4]	17	3.5%
Coal, Lignite and Peat (01) [1]	10	2.0%
Engineering (42) [4]	9	1.8%
Solar Energy (14) [1]	7	1.4%
Energy Planning, Policy, and Economy (29) [2]	7	1.4%
Radiation Protection and Dosimetry (61) [4]	7	1.4%
Atomic and Molecular Physics (74) [4]	7	1.4%
Direct Energy Conversion (30) [2]	6	1.2%
Tidal and Wave Power (16) [1]	5	1.0%
Radiology and Nuclear Medicine (62) [4]	4	0.8%
Energy Conservation, Consumption, and Utilization (32) [2]	3	0.6%
Biomass Fuels (09) [1]	2	0.4%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	2	0.4%
Energy Storage (25) [2]	2	0.4%
Particle Accelerators (43) [4]	2	0.4%
Geosciences (58) [4]	2	0.4%
Petroleum (02) [1]	1	0.2%
Natural Gas (03) [1]	1	0.2%
Hydrogen (08) [3]	1	0.2%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	1	0.2%
Fossil-Fuelled Power Plants (20) [2]	1	0.2%
Power Transmission and Distribution (24) [2]	1	0.2%
Other Instrumentation (47) [4]	1	0.2%
Applied Life Sciences (60) [4]	1	0.2%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	0	0.0%
Synthetic Fuels (10) [3]	0	0.0%
Hydro Energy (13) [1]	0	0.0%
Geothermal Energy (15) [1]	0	0.0%
Wind Energy (17) [1]	0	0.0%
Specific Nuclear Reactors and Associated Plants (21) [2]	0	0.0%
General Studies of Nuclear Reactors (22) [2]	0	0.0%
Advanced Propulsion Systems (33) [4]	0	0.0%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	0	0.0%
Chemistry (40) [4]	0	0.0%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63) [4]	0	0.0%
Physics (66) [4]	0	0.0%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	0	0.0%
Total	**491**	**100%**

Table 69: Subjects category distribution sorted per number of publications - 2004

C.11. - Year 2005

Scientific Production per resource type	#	%
Conference	123	20.0%
Journal Articles	492	80.0%
Total	**615**	**100.0%**

Table 70: Scientific production per resource type – 2005

Main Subjects Distribution	#	%
Energy Sources	34	5.5%
Energy Production, Utilization, and Management	22	3.6%
Energy Conversion and Storage	5	0.8%
Basic information developed in support of energy	554	90.1%
Total	**615**	**100.0%**

Table 71: Total scientific production per main subject - 2005

Number of Authors per Resource	#	%
1	39	6.3%
2	93	15.1%
3	135	22.0%
4	93	15.1%
5	70	11.4%
6	56	9.1%
7	37	6.0%
8	26	4.2%
9	15	2.4%
>= 10	51	8.3%

Table 72: Number of Authors per resource - 2005

Subjects Category Distribution	#	%
Coal, Lignite and Peat (01) [1]	14	2.3%
Petroleum (02) [1]	0	0.0%
Natural Gas (03) [1]	2	0.3%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	1	0.2%
Hydrogen (08) [3]	2	0.3%
Biomass Fuels (09) [1]	4	0.7%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	2	0.3%
Hydro Energy (13) [1]	2	0.3%
Solar Energy (14) [1]	6	1.0%
Geothermal Energy (15) [1]	0	0.0%
Tidal and Wave Power (16) [1]	5	0.8%
Wind Energy (17) [1]	0	0.0%
Fossil-Fuelled Power Plants (20) [2]	0	0.0%
Specific Nuclear Reactors and Associated Plants (21) [2]	2	0.3%
General Studies of Nuclear Reactors (22) [2]	0	0.0%
Power Transmission and Distribution (24) [2]	6	1.0%
Energy Storage (25) [2]	0	0.0%
Energy Planning, Policy, and Economy (29) [2]	8	1.3%
Direct Energy Conversion (30) [2]	3	0.5%
Energy Conservation, Consumption, and Utilization (32) [2]	4	0.7%
Advanced Propulsion Systems (33) [4]	1	0.2%
Materials Science (36) [4]	82	13.3%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	48	7.8%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	2	0.3%
Chemistry (40) [4]	0	0.0%
Engineering (42) [4]	13	2.1%
Particle Accelerators (43) [4]	1	0.2%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Instrumentation Related to Nuclear Science and Technology (46) [4]	15	2.4%
Other Instrumentation (47) [4]	0	0.0%
Environmental Sciences (54) [4]	25	4.1%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Geosciences (58) [4]	4	0.7%
Applied Life Sciences (60) [4]	18	2.9%
Radiation Protection and Dosimetry (61) [4]	4	0.7%
Radiology and Nuclear Medicine (62) [4]	19	3.1%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63)	1	0.2%
Physics (66) [4]	0	0.0%
Plasma Physics and Fusion Technology (70) [4]	61	9.9%
Classical and Quantum Mechanics, General Physics (71) [4]	36	5.9%
Physics of Elementary Particles and Fields (72) [4]	94	15.3%
Nuclear Physics and Radiation Physics (73) [4]	44	7.2%
Atomic and Molecular Physics (74) [4]	26	4.2%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	58	9.4%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	2	0.3%
Total	**615**	**100.0%**

Table 73: Subjects category distribution per subject order within the ETDEWEB – 2005

Subjects Category Distribution sorted	#	%
Physics of Elementary Particles and Fields (72) [4]	94	15.3%
Materials Science (36) [4]	82	13.3%
Plasma Physics and Fusion Technology (70) [4]	61	9.9%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	58	9.4%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	48	7.8%
Nuclear Physics and Radiation Physics (73) [4]	44	7.2%
Classical and Quantum Mechanics, General Physics (71) [4]	36	5.9%
Atomic and Molecular Physics (74) [4]	26	4.2%
Environmental Sciences (54) [4]	25	4.1%
Radiology and Nuclear Medicine (62) [4]	19	3.1%
Applied Life Sciences (60) [4]	18	2.9%
Instrumentation Related to Nuclear Science and Technology (46) [4]	15	2.4%
Coal, Lignite and Peat (01) [1]	14	2.3%
Engineering (42) [4]	13	2.1%
Energy Planning, Policy, and Economy (29) [2]	8	1.3%
Solar Energy (14) [1]	6	1.0%
Power Transmission and Distribution (24) [2]	6	1.0%
Tidal and Wave Power (16) [1]	5	0.8%
Biomass Fuels (09) [1]	4	0.7%
Energy Conservation, Consumption, and Utilization (32) [2]	4	0.7%
Geosciences (58) [4]	4	0.7%
Radiation Protection and Dosimetry (61) [4]	4	0.7%
Direct Energy Conversion (30) [2]	3	0.5%
Natural Gas (03) [1]	2	0.3%
Hydrogen (08) [3]	2	0.3%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	2	0.3%
Hydro Energy (13) [1]	2	0.3%
Specific Nuclear Reactors and Associated Plants (21) [2]	2	0.3%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	2	0.3%
General and Miscellaneous (99) [4]	2	0.3%
Isotopes and Radiation Sources (07) [1]	1	0.2%
Advanced Propulsion Systems (33) [4]	1	0.2%
Particle Accelerators (43) [4]	1	0.2%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63) [4]	1	0.2%
Petroleum (02) [1]	0	0.0%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Geothermal Energy (15) [1]	0	0.0%
Wind Energy (17) [1]	0	0.0%
Fossil-Fuelled Power Plants (20) [2]	0	0.0%
General Studies of Nuclear Reactors (22) [2]	0	0.0%
Energy Storage (25) [2]	0	0.0%
Chemistry (40) [4]	0	0.0%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Other Instrumentation (47) [4]	0	0.0%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Physics (66) [4]	0	0.0%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
Total	**615**	**100%**

Table 74: Subjects category distribution sorted per number of publications - 2005

C.12. - Year 2006

Scientific Production per resource type	#	%
Conference	78	10.6%
Journal Articles	656	89.4%
Total	**734**	**100.0%**

Table 75: Scientific production per resource type – 2006

Main Subjects Distribution	#	%
Energy Sources	43	5.9%
Energy Production, Utilization, and Management	17	2.3%
Energy Conversion and Storage	10	1.4%
Basic information developed in support of energy	664	90.5%
Total	**734**	**100.0%**

Table 76: Total scientific production per main subject - 2006

Number of Authors per Resource	#	%
1	52	7.1%
2	114	15.5%
3	150	20.4%
4	107	14.6%
5	70	9.5%
6	70	9.5%
7	35	4.8%
8	42	5.7%
9	24	3.3%
>= 10	70	9.5%

Table 77: Number of Authors per resource - 2006

Subjects Category Distribution	#	%
Coal, Lignite and Peat (01) [1]	10	1.4%
Petroleum (02) [1]	1	0.1%
Natural Gas (03) [1]	0	0.0%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	2	0.3%
Hydrogen (08) [3]	6	0.8%
Biomass Fuels (09) [1]	11	1.5%
Synthetic Fuels (10) [3]	1	0.1%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	2	0.3%
Hydro Energy (13) [1]	1	0.1%
Solar Energy (14) [1]	7	1.0%
Geothermal Energy (15) [1]	0	0.0%
Tidal and Wave Power (16) [1]	2	0.3%
Wind Energy (17) [1]	9	1.2%
Fossil-Fuelled Power Plants (20) [2]	1	0.1%
Specific Nuclear Reactors and Associated Plants (21) [2]	0	0.0%
General Studies of Nuclear Reactors (22) [2]	0	0.0%
Power Transmission and Distribution (24) [2]	1	0.1%
Energy Storage (25) [2]	1	0.1%
Energy Planning, Policy, and Economy (29) [2]	5	0.7%
Direct Energy Conversion (30) [2]	2	0.3%
Energy Conservation, Consumption, and Utilization (32) [2]	8	1.1%
Advanced Propulsion Systems (33) [4]	0	0.0%
Materials Science (36) [4]	111	15.1%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	48	6.5%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	0	0.0%
Chemistry (40) [4]	0	0.0%
Engineering (42) [4]	16	2.2%
Particle Accelerators (43) [4]	4	0.5%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Instrumentation Related to Nuclear Science and Technology (46) [4]	31	4.2%
Other Instrumentation (47) [4]	1	0.1%
Environmental Sciences (54) [4]	28	3.8%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Geosciences (58) [4]	4	0.5%
Applied Life Sciences (60) [4]	15	2.0%
Radiation Protection and Dosimetry (61) [4]	19	2.6%
Radiology and Nuclear Medicine (62) [4]	13	1.8%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63)	2	0.3%
Physics (66) [4]	0	0.0%
Plasma Physics and Fusion Technology (70) [4]	82	11.2%
Classical and Quantum Mechanics, General Physics (71) [4]	43	5.9%
Physics of Elementary Particles and Fields (72) [4]	122	16.6%
Nuclear Physics and Radiation Physics (73) [4]	30	4.1%
Atomic and Molecular Physics (74) [4]	24	3.3%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	67	9.1%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	4	0.5%
Total	**734**	**100.0%**

Table 78: Subjects category distribution per subject order within the ETDEWEB – 2006

Subjects Category Distribution sorted	#	%
Physics of Elementary Particles and Fields (72) [4]	122	16.6%
Materials Science (36) [4]	111	15.1%
Plasma Physics and Fusion Technology (70) [4]	82	11.2%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	67	9.1%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	48	6.5%
Classical and Quantum Mechanics, General Physics (71) [4]	43	5.9%
Instrumentation Related to Nuclear Science and Technology (46) [4]	31	4.2%
Nuclear Physics and Radiation Physics (73) [4]	30	4.1%
Environmental Sciences (54) [4]	28	3.8%
Atomic and Molecular Physics (74) [4]	24	3.3%
Radiation Protection and Dosimetry (61) [4]	19	2.6%
Engineering (42) [4]	16	2.2%
Applied Life Sciences (60) [4]	15	2.0%
Radiology and Nuclear Medicine (62) [4]	13	1.8%
Biomass Fuels (09) [1]	11	1.5%
Coal, Lignite and Peat (01) [1]	10	1.4%
Wind Energy (17) [1]	9	1.2%
Energy Conservation, Consumption, and Utilization (32) [2]	8	1.1%
Solar Energy (14) [1]	7	1.0%
Hydrogen (08) [3]	6	0.8%
Energy Planning, Policy, and Economy (29) [2]	5	0.7%
Particle Accelerators (43) [4]	4	0.5%
Geosciences (58) [4]	4	0.5%
General and Miscellaneous (99) [4]	4	0.5%
Isotopes and Radiation Sources (07) [1]	2	0.3%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	2	0.3%
Tidal and Wave Power (16) [1]	2	0.3%
Direct Energy Conversion (30) [2]	2	0.3%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63) [4]	2	0.3%
Petroleum (02) [1]	1	0.1%
Synthetic Fuels (10) [3]	1	0.1%
Hydro Energy (13) [1]	1	0.1%
Fossil-Fuelled Power Plants (20) [2]	1	0.1%
Power Transmission and Distribution (24) [2]	1	0.1%
Energy Storage (25) [2]	1	0.1%
Other Instrumentation (47) [4]	1	0.1%
Natural Gas (03) [1]	0	0.0%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Geothermal Energy (15) [1]	0	0.0%
Specific Nuclear Reactors and Associated Plants (21) [2]	0	0.0%
General Studies of Nuclear Reactors (22) [2]	0	0.0%
Advanced Propulsion Systems (33) [4]	0	0.0%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	0	0.0%
Chemistry (40) [4]	0	0.0%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Physics (66) [4]	0	0.0%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
Total	**734**	**100%**

Table 79: Subjects category distribution sorted per number of publications – 2006

C.13. - Year 2007

Scientific Production per resource type	#	%
Conference	74	9.7%
Journal Articles	688	90.3%
Total	**762**	**100.0%**

Table 80: Scientific production per resource type – 2007

Main Subjects Distribution	#	%
Energy Sources	39	5.1%
Energy Production, Utilization, and Management	28	3.7%
Energy Conversion and Storage	15	2.0%
Basic information developed in support of energy	680	89.2%
Total	**762**	**100.0%**

Table 81: Total scientific production per main subject - 2007

Number of Authors per Resource	#	%
1	51	6.7%
2	99	13.0%
3	161	21.1%
4	124	16.3%
5	92	12.1%
6	64	8.4%
7	48	6.3%
8	33	4.3%
9	18	2.4%
>= 10	72	9.4%

Table 82: Number of Authors per resource - 2007

Subjects Category Distribution	#	%
Coal, Lignite and Peat (01) [1]	7	0.9%
Petroleum (02) [1]	1	0.1%
Natural Gas (03) [1]	2	0.3%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	2	0.3%
Hydrogen (08) [3]	4	0.5%
Biomass Fuels (09) [1]	8	1.0%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	1	0.1%
Hydro Energy (13) [1]	3	0.4%
Solar Energy (14) [1]	2	0.3%
Geothermal Energy (15) [1]	0	0.0%
Tidal and Wave Power (16) [1]	12	1.6%
Wind Energy (17) [1]	2	0.3%
Fossil-Fuelled Power Plants (20) [2]	1	0.1%
Specific Nuclear Reactors and Associated Plants (21) [2]	1	0.1%
General Studies of Nuclear Reactors (22) [2]	1	0.1%
Power Transmission and Distribution (24) [2]	6	0.8%
Energy Storage (25) [2]	1	0.1%
Energy Planning, Policy, and Economy (29) [2]	13	1.7%
Direct Energy Conversion (30) [2]	10	1.3%
Energy Conservation, Consumption, and Utilization (32) [2]	5	0.7%
Advanced Propulsion Systems (33) [4]	0	0.0%
Materials Science (36) [4]	111	14.6%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	51	6.7%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	9	1.2%
Chemistry (40) [4]	0	0.0%
Engineering (42) [4]	12	1.6%
Particle Accelerators (43) [4]	3	0.4%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Instrumentation Related to Nuclear Science and Technology (46) [4]	67	8.8%
Other Instrumentation (47) [4]	0	0.0%
Environmental Sciences (54) [4]	21	2.8%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Geosciences (58) [4]	14	1.8%
Applied Life Sciences (60) [4]	35	4.6%
Radiation Protection and Dosimetry (61) [4]	4	0.5%
Radiology and Nuclear Medicine (62) [4]	12	1.6%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63)	0	0.0%
Physics (66) [4]	0	0.0%
Plasma Physics and Fusion Technology (70) [4]	58	7.6%
Classical and Quantum Mechanics, General Physics (71) [4]	66	8.7%
Physics of Elementary Particles and Fields (72) [4]	115	15.1%
Nuclear Physics and Radiation Physics (73) [4]	45	5.9%
Atomic and Molecular Physics (74) [4]	15	2.0%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	41	5.4%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	1	0.1%
Total	**762**	**100.0%**

Table 83: Subjects category distribution per subject order within the ETDEWEB – 2007

Subjects Category Distribution sorted	#	%
Physics of Elementary Particles and Fields (72) [4]	115	15.1%
Materials Science (36) [4]	111	14.6%
Instrumentation Related to Nuclear Science and Technology (46) [4]	67	8.8%
Classical and Quantum Mechanics, General Physics (71) [4]	66	8.7%
Plasma Physics and Fusion Technology (70) [4]	58	7.6%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	51	6.7%
Nuclear Physics and Radiation Physics (73) [4]	45	5.9%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	41	5.4%
Applied Life Sciences (60) [4]	35	4.6%
Environmental Sciences (54) [4]	21	2.8%
Atomic and Molecular Physics (74) [4]	15	2.0%
Geosciences (58) [4]	14	1.8%
Energy Planning, Policy, and Economy (29) [2]	13	1.7%
Tidal and Wave Power (16) [1]	12	1.6%
Engineering (42) [4]	12	1.6%
Radiology and Nuclear Medicine (62) [4]	12	1.6%
Direct Energy Conversion (30) [2]	10	1.3%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	9	1.2%
Biomass Fuels (09) [1]	8	1.0%
Coal, Lignite and Peat (01) [1]	7	0.9%
Power Transmission and Distribution (24) [2]	6	0.8%
Energy Conservation, Consumption, and Utilization (32) [2]	5	0.7%
Hydrogen (08) [3]	4	0.5%
Radiation Protection and Dosimetry (61) [4]	4	0.5%
Hydro Energy (13) [1]	3	0.4%
Particle Accelerators (43) [4]	3	0.4%
Natural Gas (03) [1]	2	0.3%
Isotopes and Radiation Sources (07) [1]	2	0.3%
Solar Energy (14) [1]	2	0.3%
Wind Energy (17) [1]	2	0.3%
Petroleum (02) [1]	1	0.1%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	1	0.1%
Fossil-Fuelled Power Plants (20) [2]	1	0.1%
Specific Nuclear Reactors and Associated Plants (21) [2]	1	0.1%
General Studies of Nuclear Reactors (22) [2]	1	0.1%
Energy Storage (25) [2]	1	0.1%
General and Miscellaneous (99) [4]	1	0.1%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Geothermal Energy (15) [1]	0	0.0%
Advanced Propulsion Systems (33) [4]	0	0.0%
Chemistry (40) [4]	0	0.0%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Other Instrumentation (47) [4]	0	0.0%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63) [4]	0	0.0%
Physics (66) [4]	0	0.0%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
Total	**762**	**100%**

Table 84: Subjects category distribution sorted per number of publications – 2007

C.14. - Year 2008

Scientific Production per resource type	#	%
Conference	78	9.9%
Journal Articles	708	90.1%
Total	**786**	**100.0%**

Table 85: Scientific production per resource type – 2008

Main Subjects Distribution	#	%
Energy Sources	56	7.1%
Energy Production, Utilization, and Management	21	2.7%
Energy Conversion and Storage	18	2.3%
Basic information developed in support of energy	691	87.9%
Total	**786**	**100.0%**

Table 86: Total scientific production per main subject - 2008

Number of Authors per Resource	#	%
1	51	6.5%
2	131	16.7%
3	150	19.1%
4	125	15.9%
5	80	10.2%
6	68	8.7%
7	37	4.7%
8	34	4.3%
9	23	2.9%
>= 10	87	11.1%

Table 87: Number of Authors per resource - 2008

Subjects Category Distribution	#	%
Coal, Lignite and Peat (01) [1]	14	1.8%
Petroleum (02) [1]	2	0.3%
Natural Gas (03) [1]	2	0.3%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	4	0.5%
Hydrogen (08) [3]	8	1.0%
Biomass Fuels (09) [1]	19	2.4%
Synthetic Fuels (10) [3]	3	0.4%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	3	0.4%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	0	0.0%
Hydro Energy (13) [1]	4	0.5%
Solar Energy (14) [1]	4	0.5%
Geothermal Energy (15) [1]	0	0.0%
Tidal and Wave Power (16) [1]	2	0.3%
Wind Energy (17) [1]	2	0.3%
Fossil-Fuelled Power Plants (20) [2]	0	0.0%
Specific Nuclear Reactors and Associated Plants (21) [2]	1	0.1%
General Studies of Nuclear Reactors (22) [2]	0	0.0%
Power Transmission and Distribution (24) [2]	5	0.6%
Energy Storage (25) [2]	1	0.1%
Energy Planning, Policy, and Economy (29) [2]	11	1.4%
Direct Energy Conversion (30) [2]	6	0.8%
Energy Conservation, Consumption, and Utilization (32) [2]	4	0.5%
Advanced Propulsion Systems (33) [4]	0	0.0%
Materials Science (36) [4]	117	14.9%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	73	9.3%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	0	0.0%
Chemistry (40) [4]	0	0.0%
Engineering (42) [4]	11	1.4%
Particle Accelerators (43) [4]	4	0.5%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Instrumentation Related to Nuclear Science and Technology (46) [4]	37	4.7%
Other Instrumentation (47) [4]	0	0.0%
Environmental Sciences (54) [4]	29	3.7%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Geosciences (58) [4]	5	0.6%
Applied Life Sciences (60) [4]	32	4.1%
Radiation Protection and Dosimetry (61) [4]	7	0.9%
Radiology and Nuclear Medicine (62) [4]	12	1.5%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63)	0	0.0%
Physics (66) [4]	0	0.0%
Plasma Physics and Fusion Technology (70) [4]	69	8.8%
Classical and Quantum Mechanics, General Physics (71) [4]	65	8.3%
Physics of Elementary Particles and Fields (72) [4]	119	15.1%
Nuclear Physics and Radiation Physics (73) [4]	37	4.7%
Atomic and Molecular Physics (74) [4]	18	2.3%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	36	4.6%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Astronomy, Cosmology and Astrophysics (79)[4]	14	1.8%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	2	0.3%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	1	0.1%
General and Miscellaneous (99) [4]	3	0.4%
Total	**786**	**100.0%**

Table 88: Subjects category distribution per subject order within the ETDEWEB – 2008

Subjects Category Distribution sorted	#	%
Physics of Elementary Particles and Fields (72) [4]	119	15.1%
Materials Science (36) [4]	117	14.9%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	73	9.3%
Plasma Physics and Fusion Technology (70) [4]	69	8.8%
Classical and Quantum Mechanics, General Physics (71) [4]	65	8.3%
Instrumentation Related to Nuclear Science and Technology (46) [4]	37	4.7%
Nuclear Physics and Radiation Physics (73) [4]	37	4.7%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	36	4.6%
Applied Life Sciences (60) [4]	32	4.1%
Environmental Sciences (54) [4]	29	3.7%
Biomass Fuels (09) [1]	19	2.4%
Atomic and Molecular Physics (74) [4]	18	2.3%
Coal, Lignite and Peat (01) [1]	14	1.8%
Astronomy, Cosmology and Astrophysics (79)[4]	14	1.8%
Radiology and Nuclear Medicine (62) [4]	12	1.5%
Energy Planning, Policy, and Economy (29) [2]	11	1.4%
Engineering (42) [4]	11	1.4%
Hydrogen (08) [3]	8	1.0%
Radiation Protection and Dosimetry (61) [4]	7	0.9%
Direct Energy Conversion (30) [2]	6	0.8%
Power Transmission and Distribution (24) [2]	5	0.6%
Geosciences (58) [4]	5	0.6%
Isotopes and Radiation Sources (07) [1]	4	0.5%
Hydro Energy (13) [1]	4	0.5%
Solar Energy (14) [1]	4	0.5%
Energy Conservation, Consumption, and Utilization (32) [2]	4	0.5%
Particle Accelerators (43) [4]	4	0.5%
Synthetic Fuels (10) [3]	3	0.4%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	3	0.4%
General and Miscellaneous (99) [4]	3	0.4%
Petroleum (02) [1]	2	0.3%
Natural Gas (03) [1]	2	0.3%
Tidal and Wave Power (16) [1]	2	0.3%
Wind Energy (17) [1]	2	0.3%
Mathematical Methods and Computing (97)[4]	2	0.3%
Specific Nuclear Reactors and Associated Plants (21) [2]	1	0.1%
Energy Storage (25) [2]	1	0.1%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	1	0.1%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	0	0.0%
Geothermal Energy (15) [1]	0	0.0%
Fossil-Fuelled Power Plants (20) [2]	0	0.0%
General Studies of Nuclear Reactors (22) [2]	0	0.0%
Advanced Propulsion Systems (33) [4]	0	0.0%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	0	0.0%
Chemistry (40) [4]	0	0.0%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Other Instrumentation (47) [4]	0	0.0%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63) [4]	0	0.0%
Physics (66) [4]	0	0.0%
Nanoscience and Nanotechnology (77)[4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Total	**786**	**100%**

Table 89: Subjects category distribution sorted per number of publications - 2008

C.15. - Year 2009

Scientific Production per resource type	#	%
Conference	91	12.7%
Journal Articles	624	87.3%
Total	**715**	**100.0%**

Table 90: Scientific production per resource type – 2009

Main Subjects Distribution	#	%
Energy Sources	43	6.0%
Energy Production, Utilization, and Management	52	7.3%
Energy Conversion and Storage	12	1.7%
Basic information developed in support of energy	608	85.0%
Total	**715**	**100.0%**

Table 91: Total scientific production per main subject - 2009

Number of Authors per Resource	#	%
1	55	7.7%
2	114	15.9%
3	130	18.2%
4	121	16.9%
5	79	11.0%
6	56	7.8%
7	30	4.2%
8	23	3.2%
9	17	2.4%
>= 10	90	12.6%

Table 92: Number of Authors per resource - 2009

Subjects Category Distribution	#	%
Coal, Lignite and Peat (01) [1]	8	1.1%
Petroleum (02) [1]	1	0.1%
Natural Gas (03) [1]	1	0.1%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	5	0.7%
Hydrogen (08) [3]	7	1.0%
Biomass Fuels (09) [1]	6	0.8%
Synthetic Fuels (10) [3]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	1	0.1%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	2	0.3%
Hydro Energy (13) [1]	0	0.0%
Solar Energy (14) [1]	2	0.3%
Geothermal Energy (15) [1]	0	0.0%
Tidal and Wave Power (16) [1]	13	1.8%
Wind Energy (17) [1]	6	0.8%
Fossil-Fuelled Power Plants (20) [2]	0	0.0%
Specific Nuclear Reactors and Associated Plants (21) [2]	0	0.0%
General Studies of Nuclear Reactors (22) [2]	0	0.0%
Power Transmission and Distribution (24) [2]	10	1.4%
Energy Storage (25) [2]	0	0.0%
Energy Planning, Policy, and Economy (29) [2]	20	2.8%
Direct Energy Conversion (30) [2]	5	0.7%
Energy Conservation, Consumption, and Utilization (32) [2]	20	2.8%
Advanced Propulsion Systems (33) [4]	2	0.3%
Materials Science (36) [4]	64	9.0%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	70	9.8%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	3	0.4%
Chemistry (40) [4]	0	0.0%
Engineering (42) [4]	9	1.3%
Particle Accelerators (43) [4]	1	0.1%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Instrumentation Related to Nuclear Science and Technology (46) [4]	39	5.5%
Other Instrumentation (47) [4]	0	0.0%
Environmental Sciences (54) [4]	27	3.8%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Geosciences (58) [4]	7	1.0%
Applied Life Sciences (60) [4]	21	2.9%
Radiation Protection and Dosimetry (61) [4]	12	1.7%
Radiology and Nuclear Medicine (62) [4]	24	3.4%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63)	4	0.6%
Physics (66) [4]	0	0.0%
Plasma Physics and Fusion Technology (70) [4]	57	8.0%
Classical and Quantum Mechanics, General Physics (71) [4]	51	7.1%
Physics of Elementary Particles and Fields (72) [4]	104	14.5%
Nuclear Physics and Radiation Physics (73) [4]	44	6.2%
Atomic and Molecular Physics (74) [4]	3	0.4%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	29	4.1%
Nanoscience and Nanotechnology (77)[4]	7	1.0%
Astronomy, Cosmology and Astrophysics (79)[4]	13	1.8%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	9	1.3%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	8	1.1%
Total	**715**	**100.0%**

Table 93: Subjects category distribution per subject order within the ETDEWEB – 2009

Subjects Category Distribution sorted	#	%
Physics of Elementary Particles and Fields (72) [4]	104	14.5%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	70	9.8%
Materials Science (36) [4]	64	9.0%
Plasma Physics and Fusion Technology (70) [4]	57	8.0%
Classical and Quantum Mechanics, General Physics (71) [4]	51	7.1%
Nuclear Physics and Radiation Physics (73) [4]	44	6.2%
Instrumentation Related to Nuclear Science and Technology (46) [4]	39	5.5%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	29	4.1%
Environmental Sciences (54) [4]	27	3.8%
Radiology and Nuclear Medicine (62) [4]	24	3.4%
Applied Life Sciences (60) [4]	21	2.9%
Energy Planning, Policy, and Economy (29) [2]	20	2.8%
Energy Conservation, Consumption, and Utilization (32) [2]	20	2.8%
Tidal and Wave Power (16) [1]	13	1.8%
Astronomy, Cosmology and Astrophysics (79)[4]	13	1.8%
Radiation Protection and Dosimetry (61) [4]	12	1.7%
Power Transmission and Distribution (24) [2]	10	1.4%
Engineering (42) [4]	9	1.3%
Mathematical Methods and Computing (97)[4]	9	1.3%
Coal, Lignite and Peat (01) [1]	8	1.1%
General and Miscellaneous (99) [4]	8	1.1%
Hydrogen (08) [3]	7	1.0%
Geosciences (58) [4]	7	1.0%
Nanoscience and Nanotechnology (77)[4]	7	1.0%
Biomass Fuels (09) [1]	6	0.8%
Wind Energy (17) [1]	6	0.8%
Isotopes and Radiation Sources (07) [1]	5	0.7%
Direct Energy Conversion (30) [2]	5	0.7%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63) [4]	4	0.6%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	3	0.4%
Atomic and Molecular Physics (74) [4]	3	0.4%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	2	0.3%
Solar Energy (14) [1]	2	0.3%
Advanced Propulsion Systems (33) [4]	2	0.3%
Petroleum (02) [1]	1	0.1%
Natural Gas (03) [1]	1	0.1%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	1	0.1%
Particle Accelerators (43) [4]	1	0.1%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Synthetic Fuels (10) [3]	0	0.0%
Hydro Energy (13) [1]	0	0.0%
Geothermal Energy (15) [1]	0	0.0%
Fossil-Fuelled Power Plants (20) [2]	0	0.0%
Specific Nuclear Reactors and Associated Plants (21) [2]	0	0.0%
General Studies of Nuclear Reactors (22) [2]	0	0.0%
Energy Storage (25) [2]	0	0.0%
Chemistry (40) [4]	0	0.0%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Other Instrumentation (47) [4]	0	0.0%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Physics (66) [4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
Total	**715**	**100%**

Table 94: Subjects category distribution sorted per number of publications - 2009

C.16. - Year 2010

Scientific Production per resource type	#	%
Conference	3	1.2%
Journal Articles	241	98.8%
Total	**244**	**100.0%**

Table 95: Scientific production per resource type – 2010

Main Subjects Distribution	#	%
Energy Sources	37	15.2%
Energy Production, Utilization, and Management	34	13.9%
Energy Conversion and Storage	21	8.6%
Basic information developed in support of energy	152	62.3%
Total	**244**	**100.0%**

Table 96: Total scientific production per main subject - 2010

Number of Authors per Resource	#	%
1	15	6.1%
2	43	17.6%
3	54	22.1%
4	28	11.5%
5	28	11.5%
6	23	9.4%
7	9	3.7%
8	9	3.7%
9	8	3.3%
>= 10	27	11.1%

Table 97: Number of Authors per resource - 2010

Subjects Category Distribution	#	%
Coal, Lignite and Peat (01) [1]	6	2.5%
Petroleum (02) [1]	1	0.4%
Natural Gas (03) [1]	0	0.0%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Isotopes and Radiation Sources (07) [1]	3	1.2%
Hydrogen (08) [3]	9	3.7%
Biomass Fuels (09) [1]	6	2.5%
Synthetic Fuels (10) [3]	1	0.4%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	0	0.0%
Hydro Energy (13) [1]	4	1.6%
Solar Energy (14) [1]	8	3.3%
Geothermal Energy (15) [1]	1	0.4%
Tidal and Wave Power (16) [1]	3	1.2%
Wind Energy (17) [1]	5	2.0%
Fossil-Fuelled Power Plants (20) [2]	3	1.2%
Specific Nuclear Reactors and Associated Plants (21) [2]	0	0.0%
General Studies of Nuclear Reactors (22) [2]	2	0.8%
Power Transmission and Distribution (24) [2]	13	5.3%
Energy Storage (25) [2]	0	0.0%
Energy Planning, Policy, and Economy (29) [2]	8	3.3%
Direct Energy Conversion (30) [2]	11	4.5%
Energy Conservation, Consumption, and Utilization (32) [2]	8	3.3%
Advanced Propulsion Systems (33) [4]	2	0.8%
Materials Science (36) [4]	54	22.1%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	18	7.4%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	0	0.0%
Chemistry (40) [4]	0	0.0%
Engineering (42) [4]	4	1.6%
Particle Accelerators (43) [4]	0	0.0%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Instrumentation Related to Nuclear Science and Technology (46) [4]	8	3.3%
Other Instrumentation (47) [4]	0	0.0%
Environmental Sciences (54) [4]	9	3.7%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Geosciences (58) [4]	2	0.8%
Applied Life Sciences (60) [4]	0	0.0%
Radiation Protection and Dosimetry (61) [4]	1	0.4%
Radiology and Nuclear Medicine (62) [4]	9	3.7%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63)	0	0.0%
Physics (66) [4]	0	0.0%
Plasma Physics and Fusion Technology (70) [4]	6	2.5%
Classical and Quantum Mechanics, General Physics (71) [4]	7	2.9%
Physics of Elementary Particles and Fields (72) [4]	18	7.4%
Nuclear Physics and Radiation Physics (73) [4]	5	2.0%
Atomic and Molecular Physics (74) [4]	0	0.0%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	5	2.0%
Nanoscience and Nanotechnology (77)[4]	1	0.4%
Astronomy, Cosmology and Astrophysics (79)[4]	3	1.2%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	0	0.0%
Total	**244**	**100.0%**

Table 98: Subjects category distribution per subject order within the ETDEWEB – 2010

Subjects Category Distribution sorted	#	%
Materials Science (36) [4]	54	22.1%
Inorganic, Organic, Physical and Analytical Chemistry (37) [4]	18	7.4%
Physics of Elementary Particles and Fields (72) [4]	18	7.4%
Power Transmission and Distribution (24) [2]	13	5.3%
Direct Energy Conversion (30) [2]	11	4.5%
Hydrogen (08) [3]	9	3.7%
Environmental Sciences (54) [4]	9	3.7%
Radiology and Nuclear Medicine (62) [4]	9	3.7%
Solar Energy (14) [1]	8	3.3%
Energy Planning, Policy, and Economy (29) [2]	8	3.3%
Energy Conservation, Consumption, and Utilization (32) [2]	8	3.3%
Instrumentation Related to Nuclear Science and Technology (46) [4]	8	3.3%
Classical and Quantum Mechanics, General Physics (71) [4]	7	2.9%
Coal, Lignite and Peat (01) [1]	6	2.5%
Biomass Fuels (09) [1]	6	2.5%
Plasma Physics and Fusion Technology (70) [4]	6	2.5%
Wind Energy (17) [1]	5	2.0%
Nuclear Physics and Radiation Physics (73) [4]	5	2.0%
Condensed Matter Physics, Superconductivity and Super fluidity (75) [4]	5	2.0%
Hydro Energy (13) [1]	4	1.6%
Engineering (42) [4]	4	1.6%
Isotopes and Radiation Sources (07) [1]	3	1.2%
Tidal and Wave Power (16) [1]	3	1.2%
Fossil-Fuelled Power Plants (20) [2]	3	1.2%
Astronomy, Cosmology and Astrophysics (79)[4]	3	1.2%
General Studies of Nuclear Reactors (22) [2]	2	0.8%
Advanced Propulsion Systems (33) [4]	2	0.8%
Geosciences (58) [4]	2	0.8%
Petroleum (02) [1]	1	0.4%
Synthetic Fuels (10) [3]	1	0.4%
Geothermal Energy (15) [1]	1	0.4%
Radiation Protection and Dosimetry (61) [4]	1	0.4%
Nanoscience and Nanotechnology (77)[4]	1	0.4%
Natural Gas (03) [1]	0	0.0%
Oil Shales and Tar Sands (04) [1]	0	0.0%
Nuclear Fuel Cycle and Fuel Materials (11) [1]	0	0.0%
Management of Radioactive Wastes, and Non-Radioactive Wastes from Nuclear Facilities (12) [2]	0	0.0%
Specific Nuclear Reactors and Associated Plants (21) [2]	0	0.0%
Energy Storage (25) [2]	0	0.0%
Radiation Chemistry, Radiochemistry and Nuclear Chemistry (38) [4]	0	0.0%
Chemistry (40) [4]	0	0.0%
Particle Accelerators (43) [4]	0	0.0%
Instrumentation (44) [4]	0	0.0%
Military Technology (45) [4]	0	0.0%
Other Instrumentation (47) [4]	0	0.0%
Biology and Medicine (55) [4]	0	0.0%
Biology and Medicine (56) [4]	0	0.0%
Applied Life Sciences (60) [4]	0	0.0%
Radiation, Thermal, and other Environmental Pollutant Effects on Living Organisms and Biological Materials (63) [4]	0	0.0%
Physics (66) [4]	0	0.0%
Atomic and Molecular Physics (74) [4]	0	0.0%
Knowledge Management and Preservation (96) [4]	0	0.0%
Mathematical Methods and Computing (97)[4]	0	0.0%
Nuclear Disarmament, Safeguards and Physical Protection (98) [4]	0	0.0%
General and Miscellaneous (99) [4]	0	0.0%
Total	**244**	**100%**

Table 99: Subjects category distribution sorted per number of publications - 2010

Appendix D – Social Network Analysis per year

D.1. - Year 1995

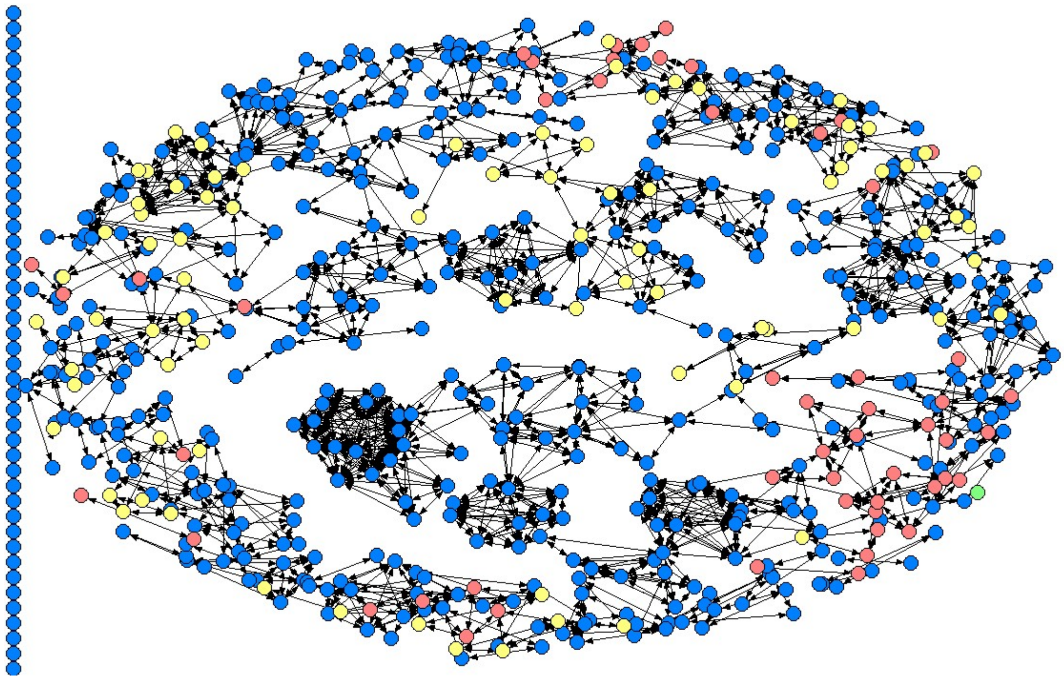


Figure 21: Energy field community co-authorship social network (1995) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

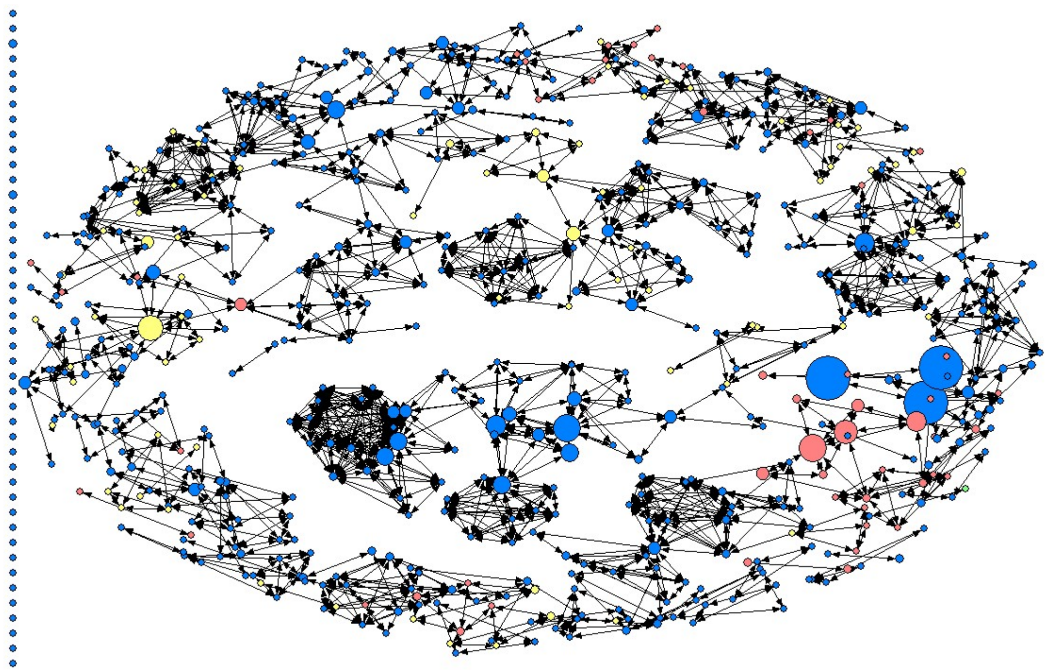


Figure 22: Number of Publications - Energy field community co-authorship social network (1995) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

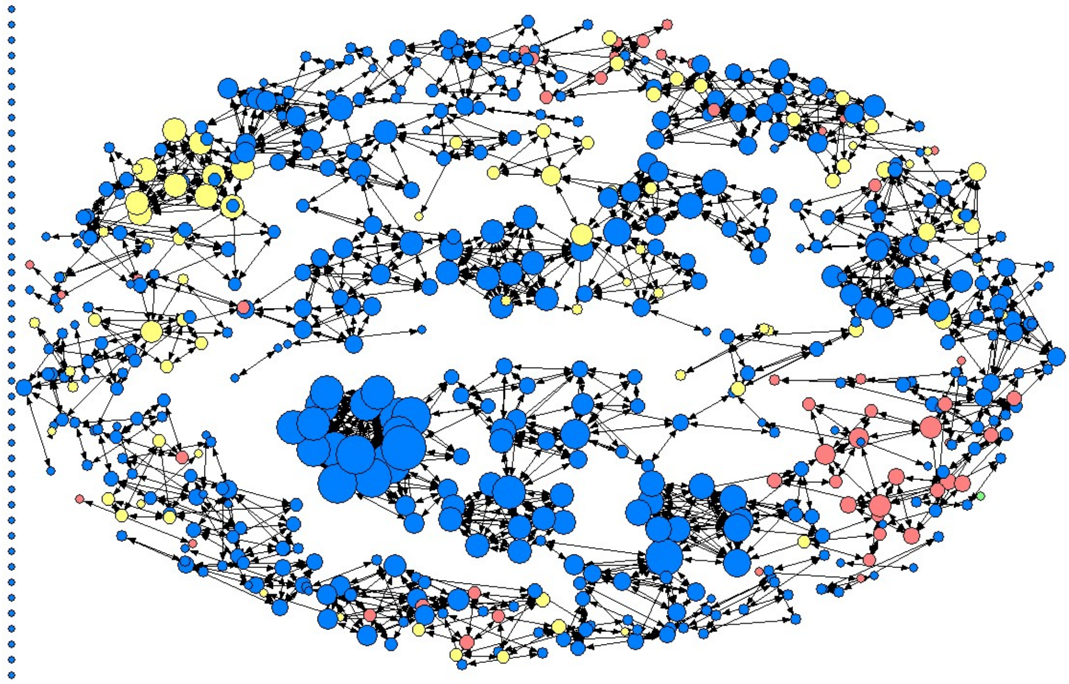


Figure 23: Degree Centrality - Energy field community co-authorship social network (1995) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

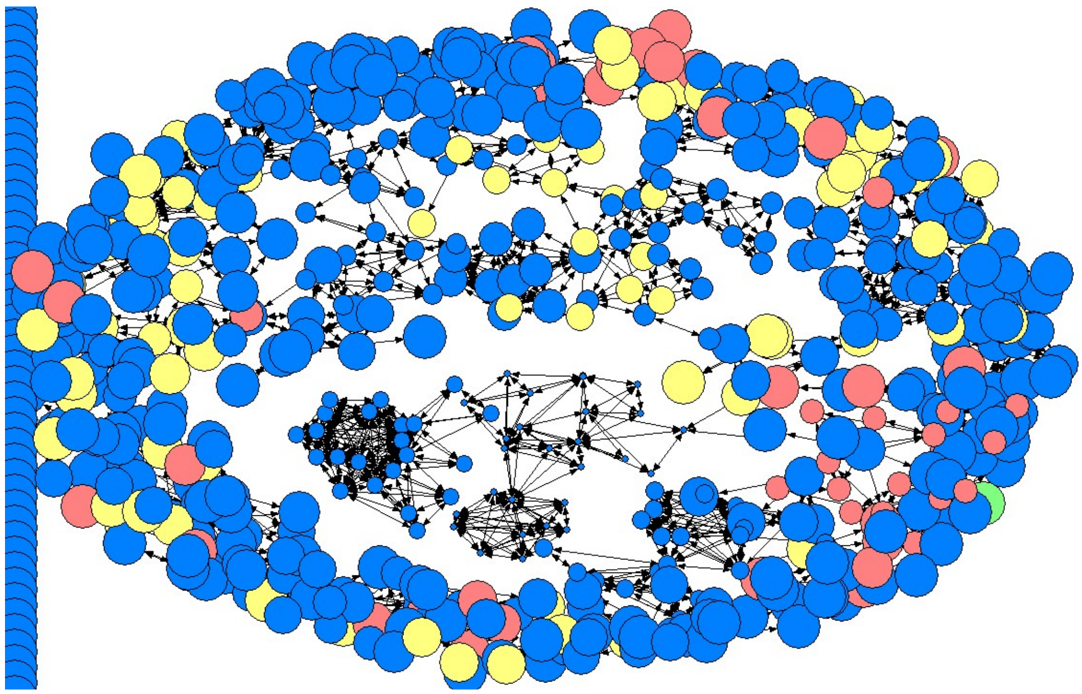


Figure 24: Closeness Centrality - Energy field community co-authorship social network (1995) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

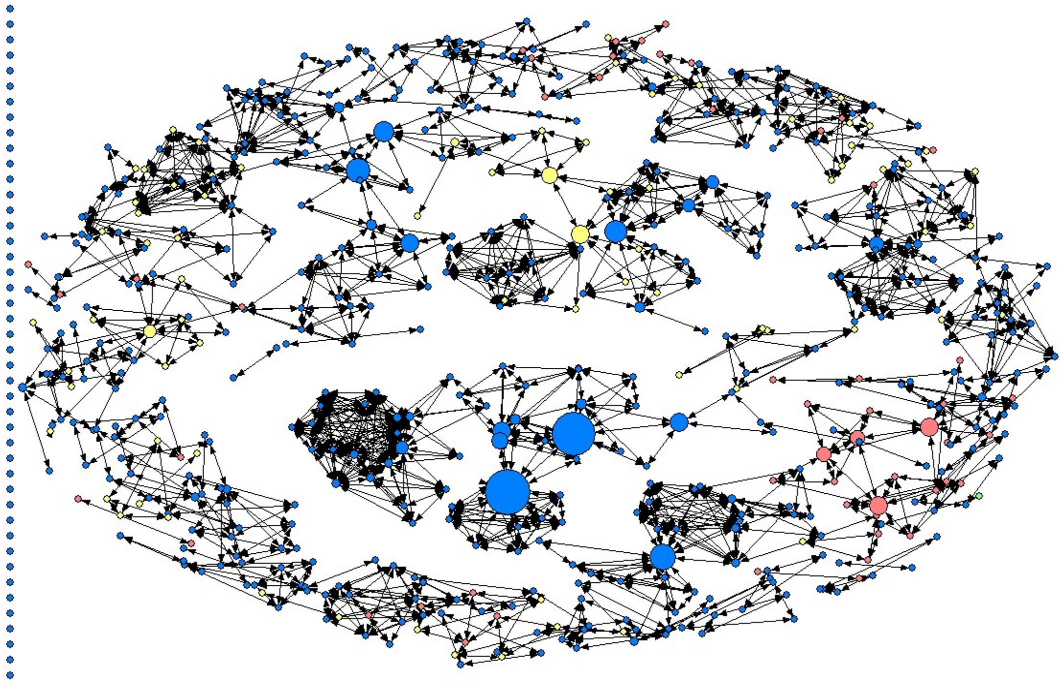


Figure 25: Betweeness Centrality - Energy field community co-authorship social network (1995) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

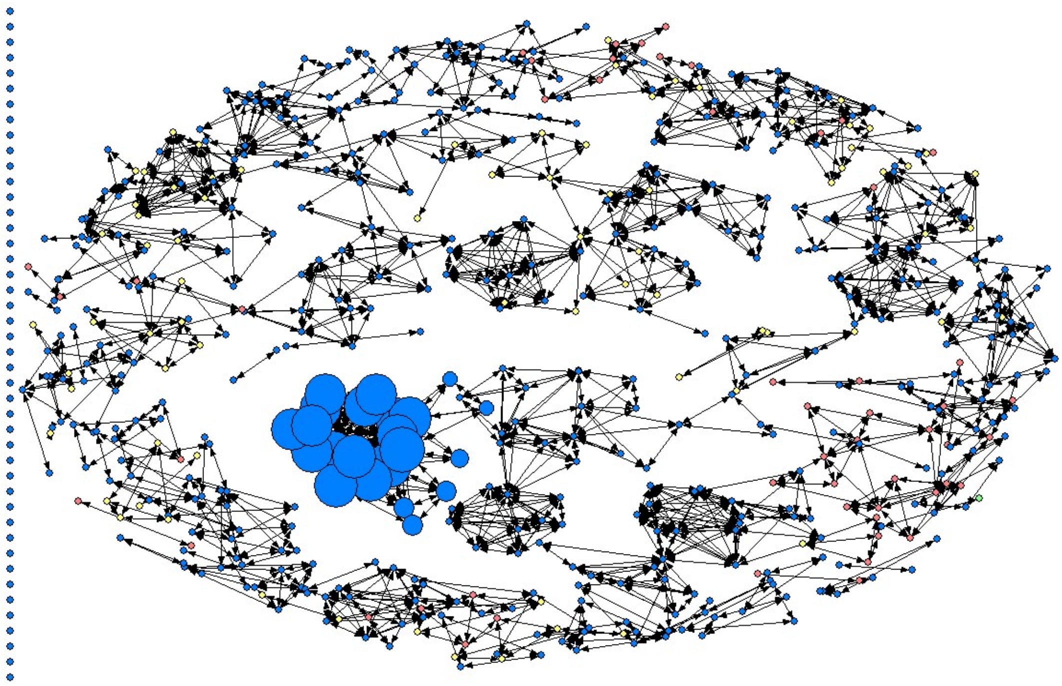


Figure 26: Eigenvector Centrality - Energy field community co-authorship social network (1995) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

Number of papers			Degree			Betwenness			Eigenvector		
15	Abreu,P.	IST - UTL	21	Policarpo,A.J.P.L	UC	171	Godinho,M.	UL	0,265	Policarpo,A.J.P.L	UC
15	Adam,W.	AAS	19	FerreiraMarques,R.	LIP-Coimbra	160	Almeida,M.	ITN	0,259	FerreiraMarques,R.	LIP-Coimbra
15	Adye,T.	RAL	18	Chepel,V.	UC	87	Correia,C.	UC	0,254	Fraga,F.A.F.	LIP-Coimbra
9	Almeida,M.	ITN	18	Lopes,M.I.	UC	81	DaSilva,M.F.	ITN	0,254	Fraga,M.M.F.R.	LIP-Coimbra
9	Gulyurtlu,I.	INETI	18	Fraga,F.A.F.	LIP-Coimbra	66	Sousa,J.B.	UP	0,254	Silander,K.	UC
8	Carvalho,M.G.	IST - UTL	18	Fraga,M.M.F.R.	LIP-Coimbra	56	Soares,J.C.	UL	0,248	Chepel,V.	UC
7	Cabrita,I.	INETI	18	Silander,K.	UC	55	Mendes,J.F.	INETI	0,248	Lopes,M.I.	UC
6	GuedesSoares,C.	IST - UTL	17	Correia,C.	UC	52	Alcacer,L.	IST - UTL	0,242	Alves,M.A.	UC
6	Lobo,L.S.	UNL	16	Alves,M.A.	UC	52	Andritschky,M.	UMi	0,237	Araujo,H.	UC
6	Spirlet,J.C.	ITE-JRC	15	Godinho,M.	UL	50	Spirlet,J.C.	ITE-JRC	0,237	Fonte,P.	LIP-Coimbra

Table 100: The authors with highest number of papers, degree, betweeness and eigenvector centralities (1995)

D.2. - Year 1996

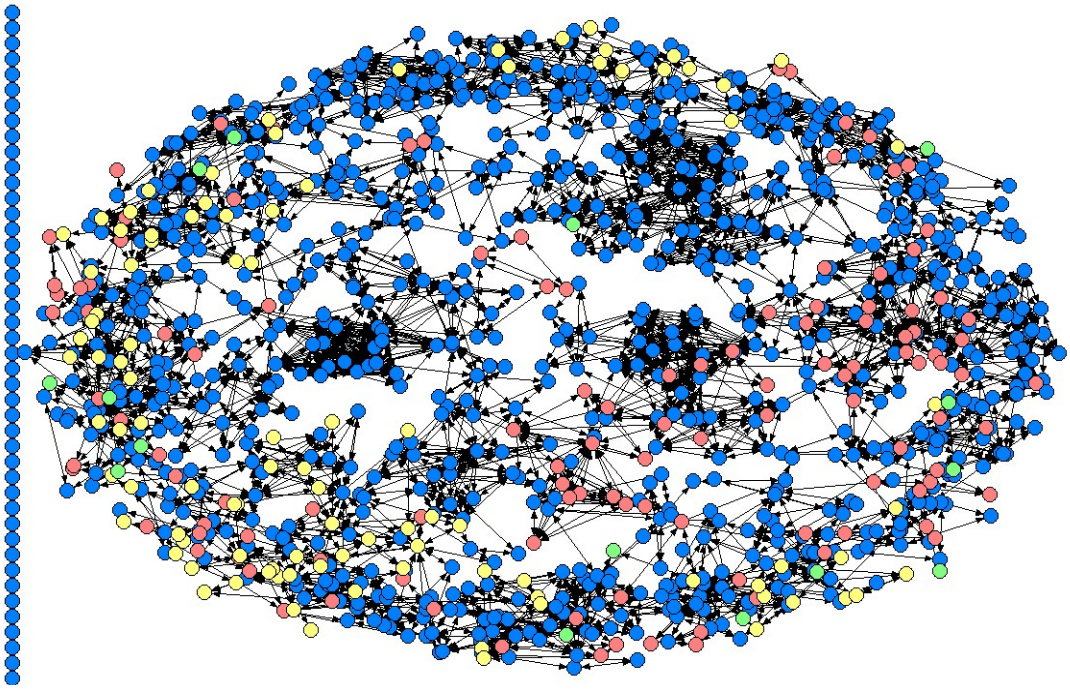


Figure 27: Energy field community co-authorship social network evolution (1995-1996) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

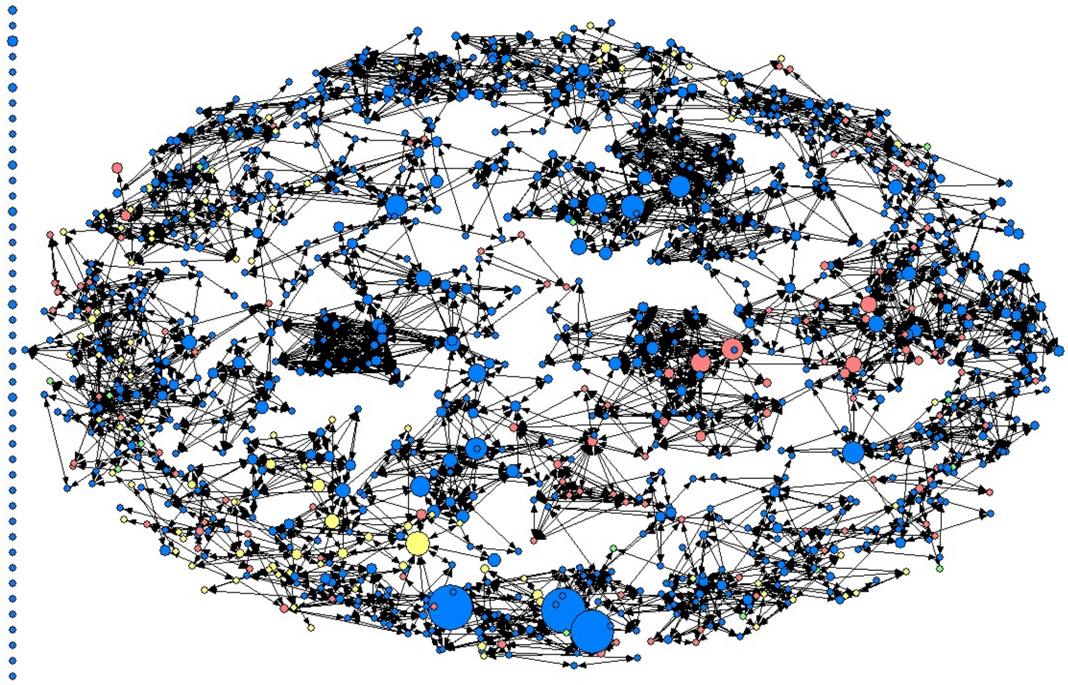


Figure 28: Number of Publications - Energy field community co-authorship social network evolution (1995-1996) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

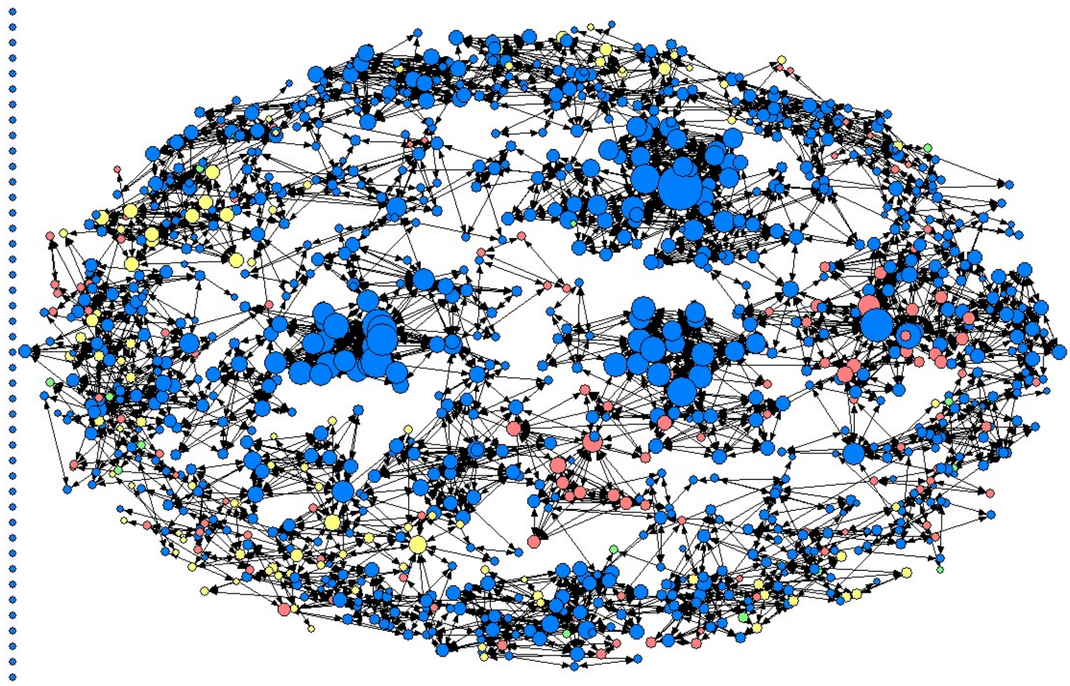


Figure 29: Degree Centrality - Energy field community co-authorship social network evolution (1995-1996) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

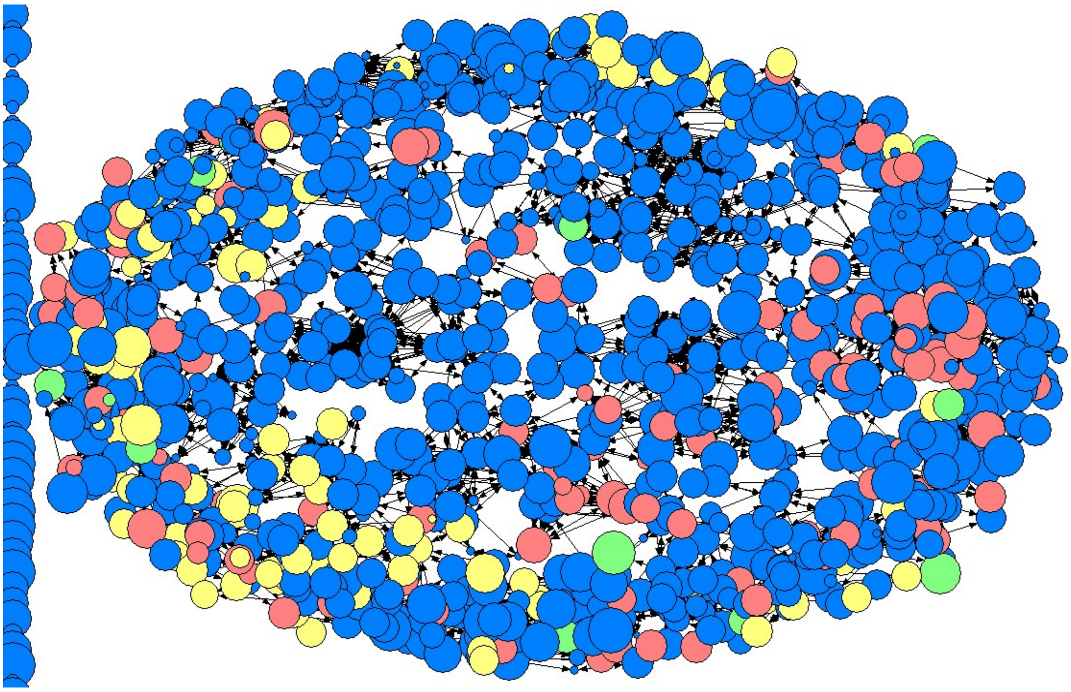


Figure 30: Closeness Centrality - Energy field community co-authorship social network evolution (1995-1996) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

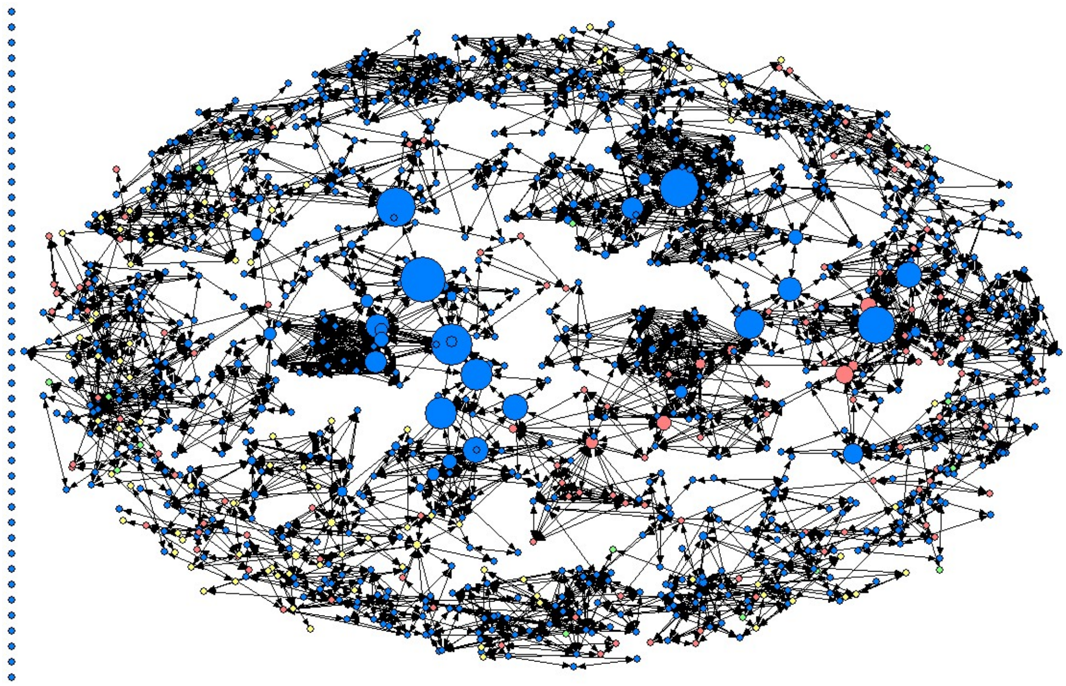


Figure 31: Betweeness Centrality - Energy field community co-authorship social network evolution (1995-1996) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

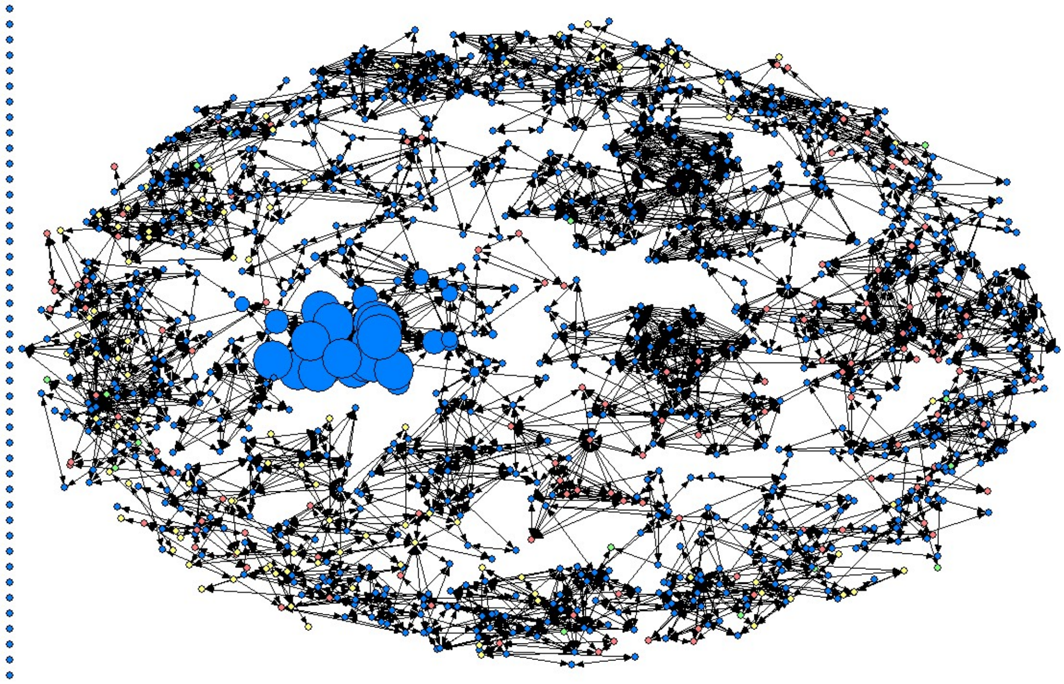


Figure 32: Eigenvector Centrality - Energy field community co-authorship social network evolution (1995-1996) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

Number of papers			Degree			Betwenness			Eigenvector		
25	Abreu,P.	IST - UTL	41	Godinho,M.	UL	958	Varandas,C.A.F.	EURATOM IST - UTL	0,256	Manso,M.E.	EURATOM IST - UTL
25	Adam,W.	AAS	29	Manso,M.E.	EURATOM IST - UTL	841	Correia,C.M.B.A.	LIP-Coimbra	0,254	Varela,P.	EURATOM IST - UTL
24	Adye,T.	RAL	28	Soares,J.C.	UL	826	Mendonca,J.T.	IST - UTL	0,252	Silva,A	EURATOM IST - UTL
12	Almeida,M.	ITN	26	Silva,A	EURATOM IST - UTL	792	Godinho,M.	UL	0,251	Serra,F.	EURATOM IST - UTL
12	Carvalho,M.G.	IST - UTL	26	Varela,P.	EURATOM IST - UTL	743	Soares,J.C.	UL	0,236	Cupido,L.	EURATOM IST - UTL
11	Conde,C.A.N.	UC	25	Serra,F.	EURATOM IST - UTL	636	Simoes,P.C.P.S.	UC	0,236	Loureiro,C.	EURATOM IST - UTL
11	Gulyurtlu,I.	INETI	24	Estrela,P.	UL	634	Simoes,J.B.	UC	0,236	Santos,J.	EURATOM IST - UTL
11	Mendonca,J.T.	IST - UTL	24	Peskov,V.	NASA - MSFC	581	Conde,O.	UL	0,215	Fernandes,J.	EURATOM IST - UTL
10	Godinho,M.	UL	21	Policarpo,A.J.P.L	UC	492	Silva,RuiA.	UP	0,212	Albrecht,M.	EURATOM IST - UTL
10	GuedesSoares,C.	IST - UTL	21	Cupido,L.	EURATOM IST - UTL	466	Conde,C.A.N.	UC	0,212	Eusebio,F.	EURATOM IST - UTL

Table 101: The authors with highest number of papers, degree, betweeness and eigenvector centralities (1995-1996)

D.3. - Year 1997

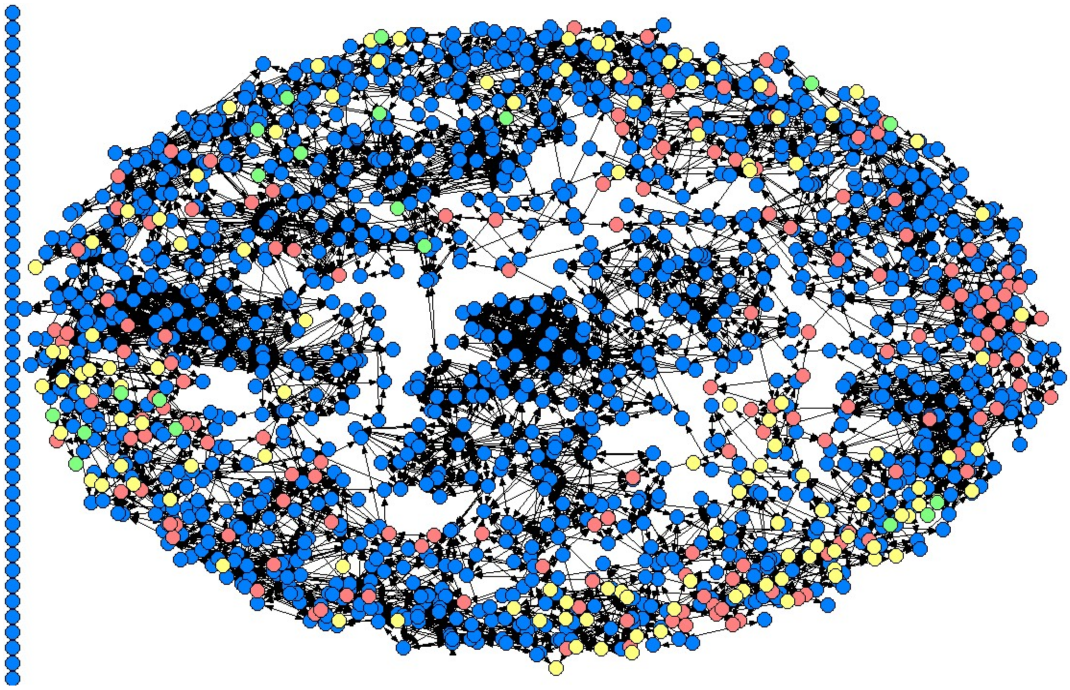


Figure 33: Energy field community co-authorship social network evolution (1995-1997) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

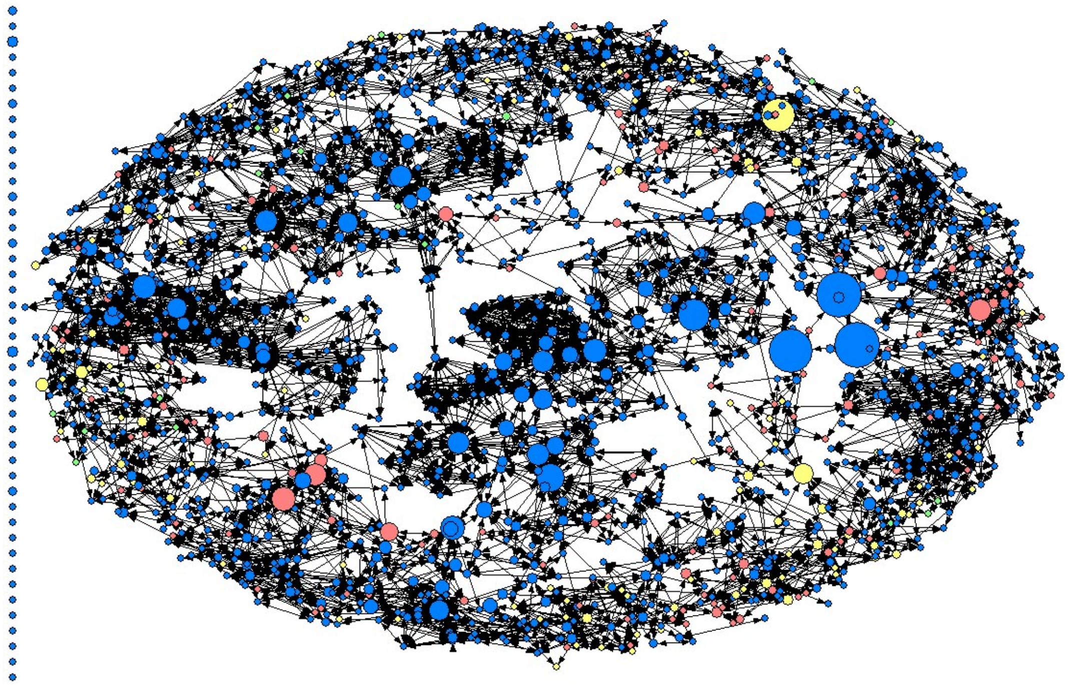


Figure 34: Number of Publications - Energy field community co-authorship social network evolution (1995-1997) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

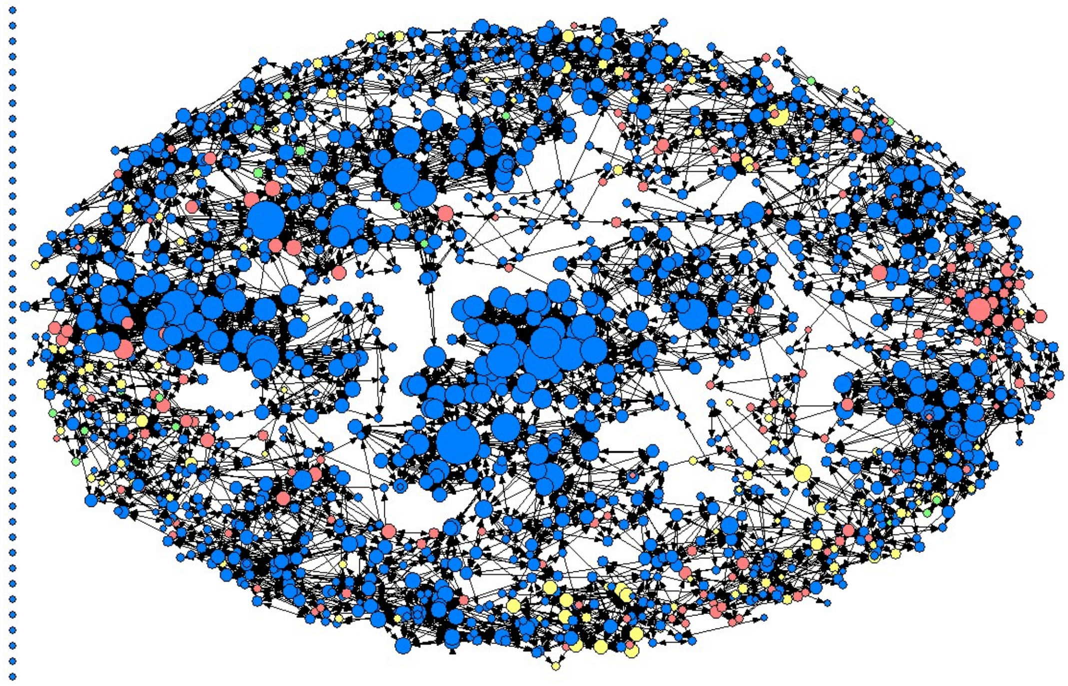


Figure 35: Degree Centrality - Energy field community co-authorship social network evolution (1995-1997) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

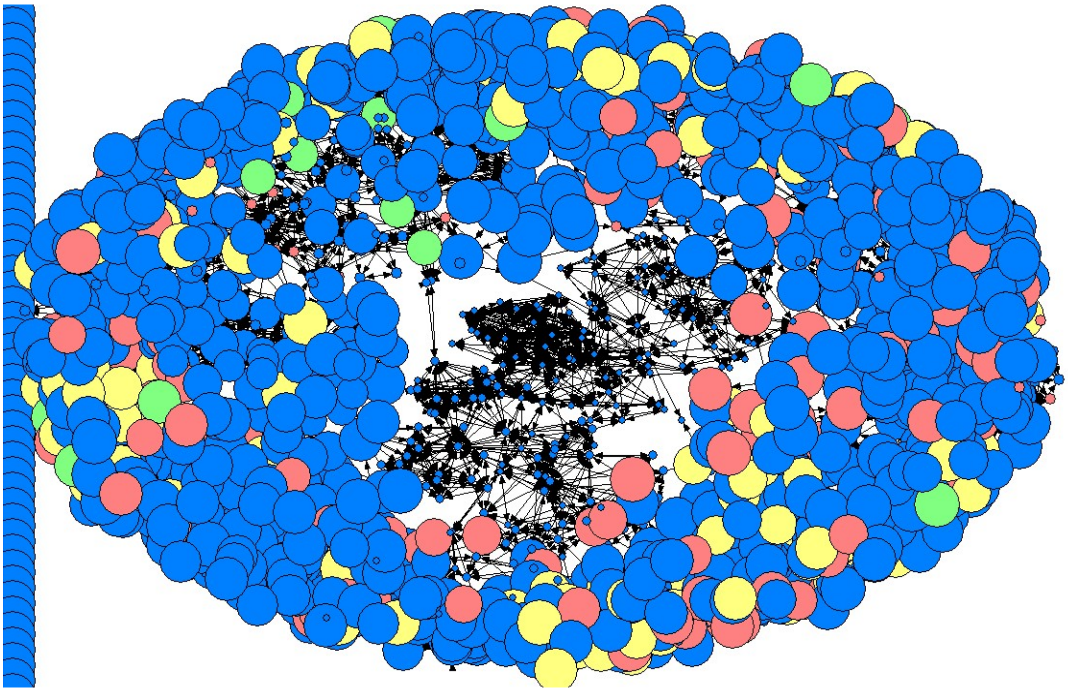


Figure 36: Closeness Centrality - Energy field community co-authorship social network evolution (1995-1997) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

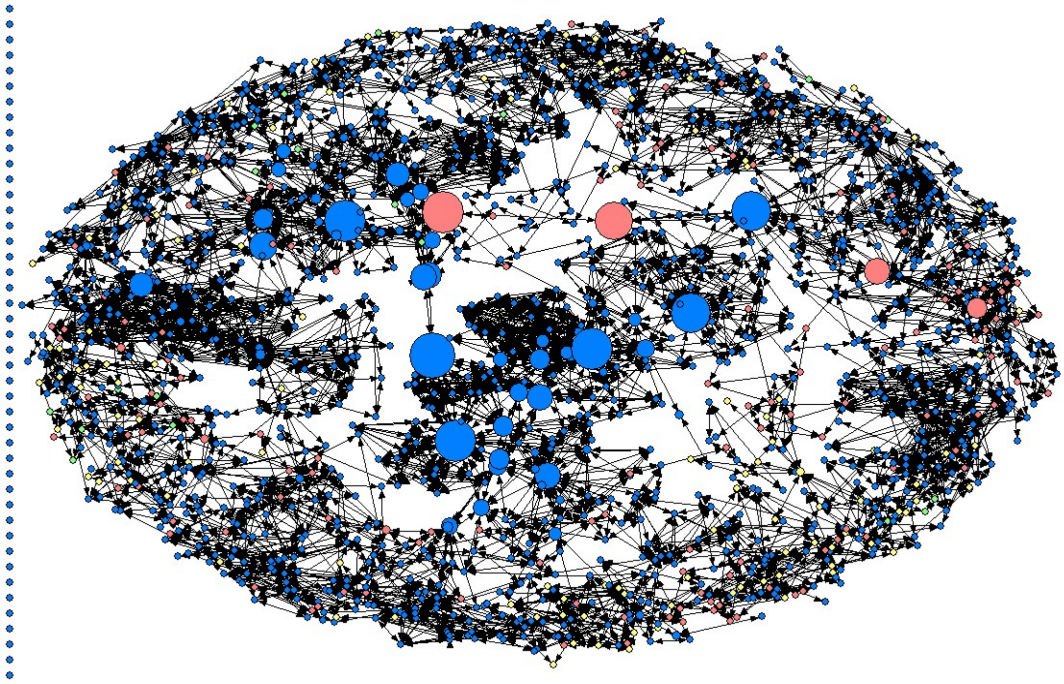


Figure 37: Betweeness Centrality - Energy field community co-authorship social network evolution (1995-1997) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

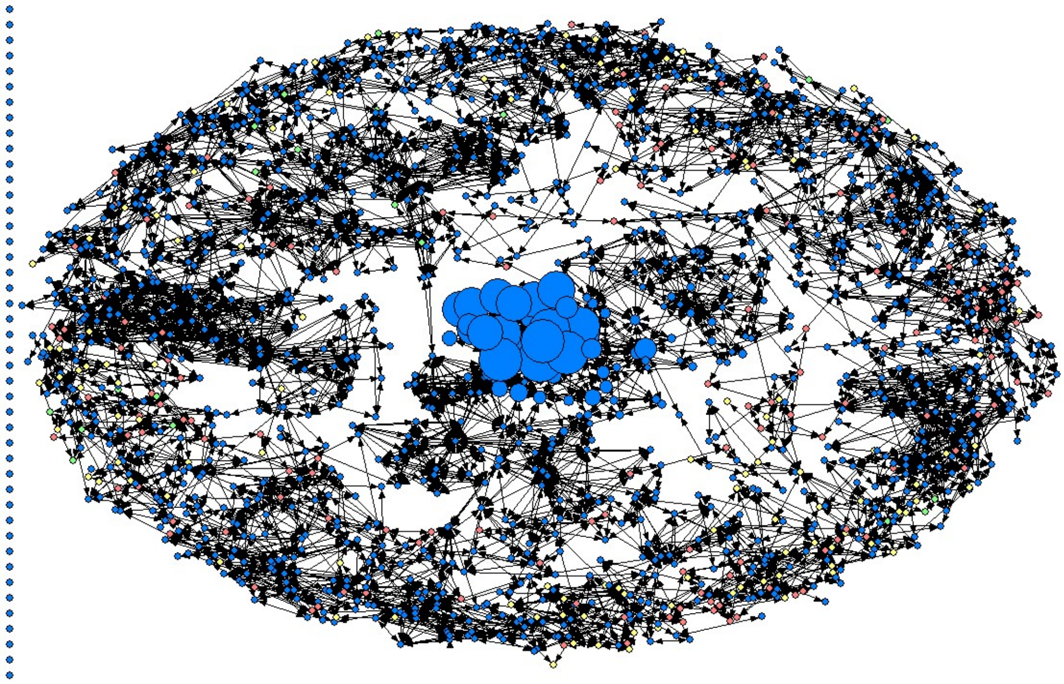


Figure 38: Eigenvector Centrality - Energy field community co-authorship social network evolution (1995-1997) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

Number of papers			Degree			Betwenness			Eigenvector		
25	Abreu,P.	IST - UTL	41	Godinho,M.	UL	3174	AyresdeCampos,N.	UC	0,262	Manso,M.E.	EURATOM IST - UTL
25	Adam,W.	AAS	35	Manso,M.E.	EURATOM IST - UTL	2915	DaSilva,M.F.	ITN	0,255	Silva,A	EURATOM IST - UTL
24	Adye,T.	RAL	35	Soares,J.C.	UL	2840	Soares,C.G.	IST - UTL	0,254	Serra,F.	EURATOM IST - UTL
18	Carvalho,M.G.	IST - UTL	32	Sousa,J.B.	UP	2804	Varandas,C.A.F.	EURATOM IST - UTL	0,250	Varela,P.	EURATOM IST - UTL
17	Mendonca,J.T.	IST - UTL	30	DaSilva,M.F.	ITN	2796	Godinho,M.	UL	0,238	Loureiro,C.	EURATOM IST - UTL
14	Almeida,M.	ITN	30	Policarpo,A.J.P.L	UC	2668	GuedesSoares,C.	IST - UTL	0,233	Cupido,L.	EURATOM IST - UTL
12	Conde,C.A.N.	UC	29	Silva,A	EURATOM IST - UTL	2624	Mendonca,J.T.	IST - UTL	0,232	Santos,J.	EURATOM IST - UTL
12	Gulyurtlu,I.	INETI	28	Serra,F.	EURATOM IST - UTL	2590	Shetty,N.K.	AMC	0,215	Nunes,I.	EURATOM IST - UTL
12	Varandas,C.A.F.	EURATOM IST - UTL	28	Peskov,V.	NASA - MSFC	1744	Conde,O.	UL	0,208	Kurzan,B.	EURATOM IPP
12	Vilar,Rui	IST - UTL	27	Mendonca,J.T.	IST - UTL	1639	Barstow,S.F.	OCEANOR S.A.	0,208	Suttrop,W.	EURATOM IPP

Table 102: The authors with highest number of papers, degree, betweeness and eigenvector centralities (1995-1997)

D.4. - Year 1998

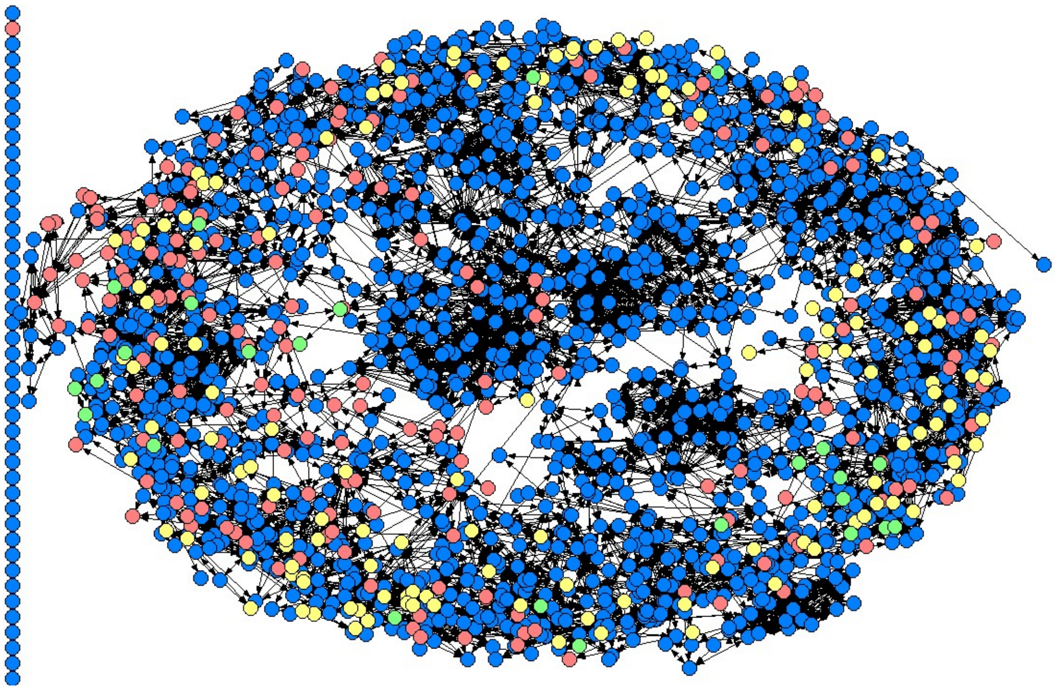


Figure 39: Energy field community co-authorship social network evolution (1995-1998) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

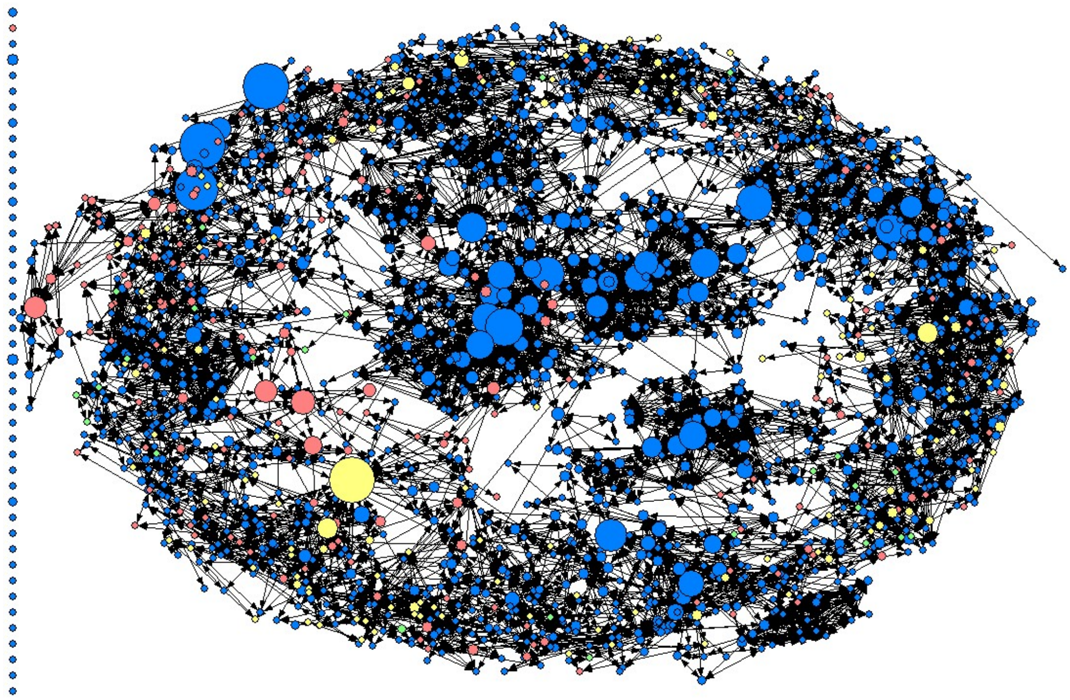


Figure 40: Number of Publications - Energy field community co-authorship social network evolution (1995-1998) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

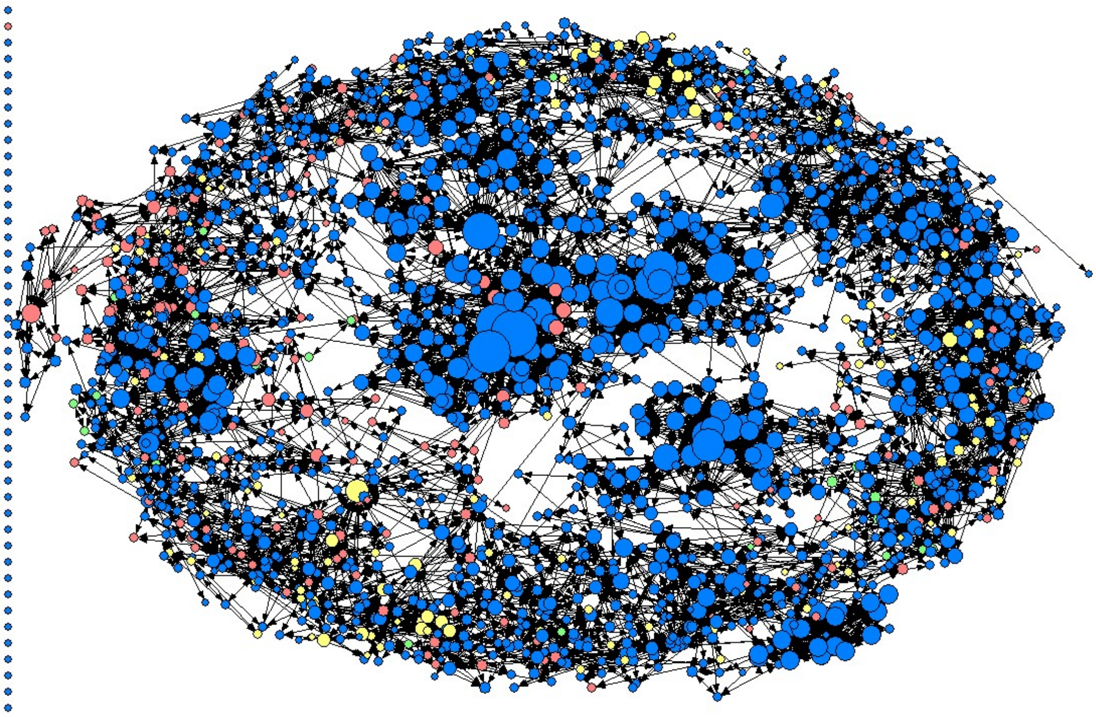


Figure 41: Degree Centrality - Energy field community co-authorship social network evolution (1995-1998) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

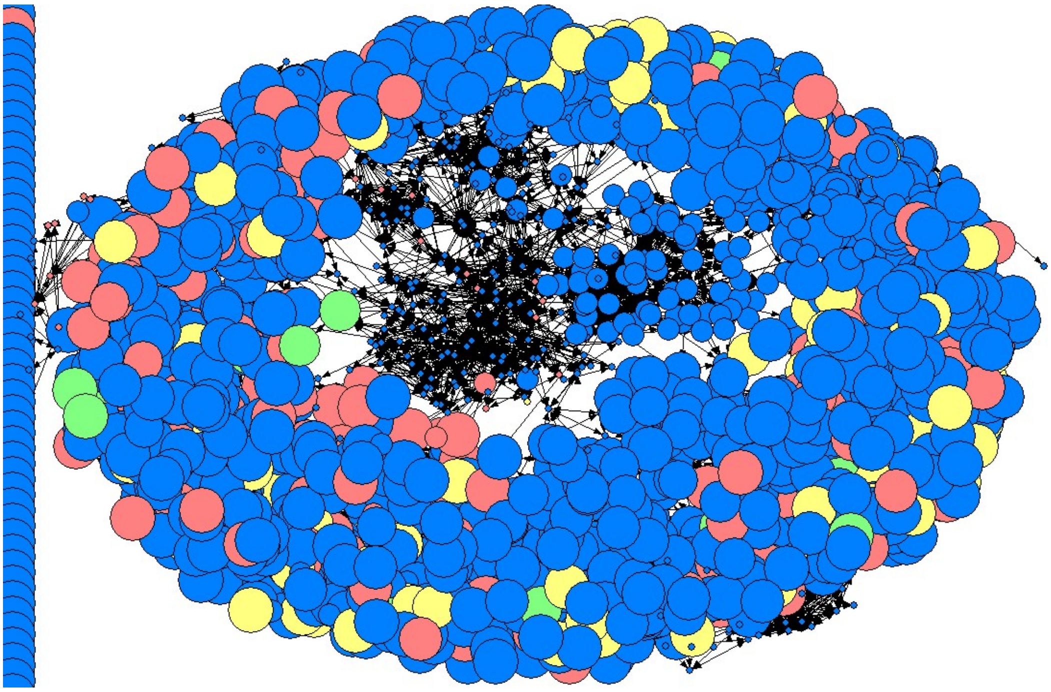


Figure 42: Closeness Centrality - Energy field community co-authorship social network evolution (1995-1998) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

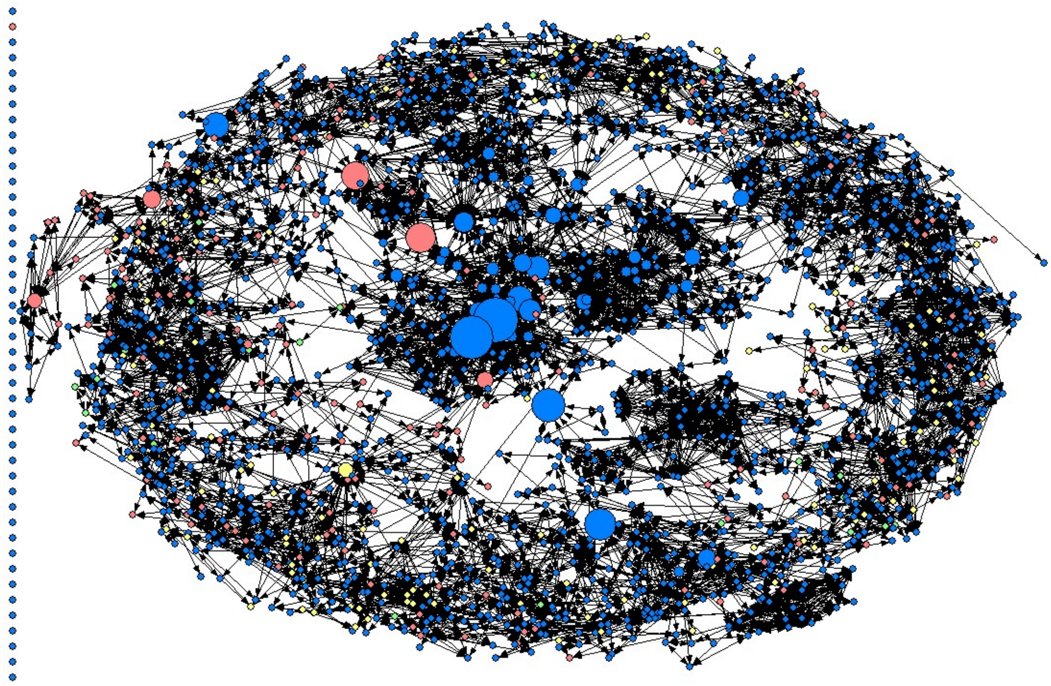


Figure 43: Betweeness Centrality - Energy field community co-authorship social network evolution (1995-1998) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

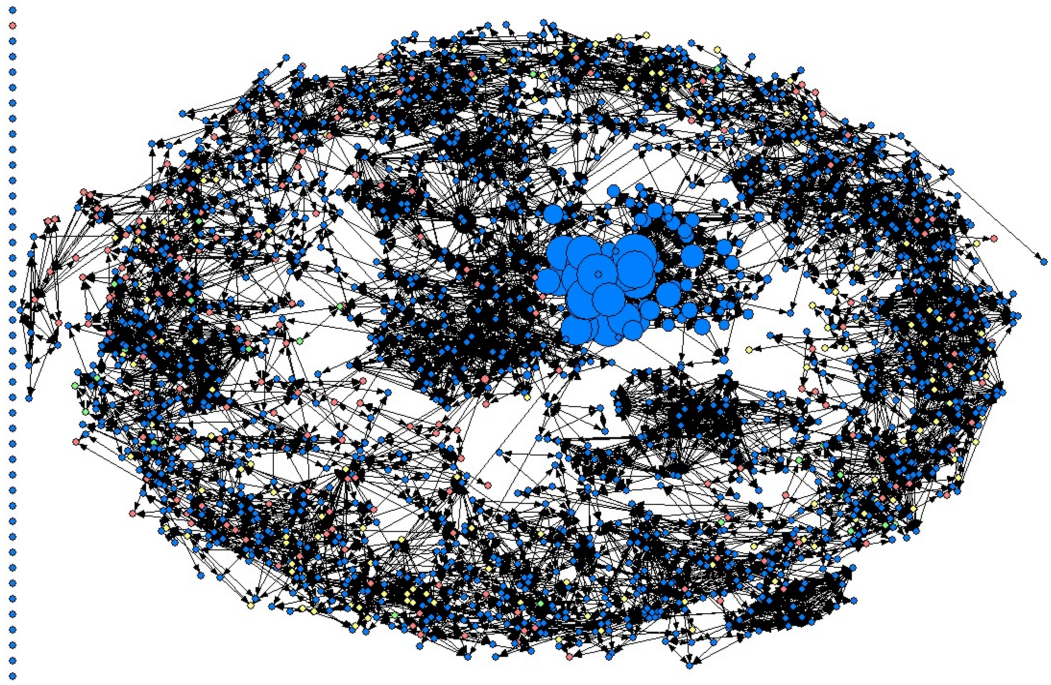


Figure 44: Eigenvector Centrality - Energy field community co-authorship social network evolution (1995-1998) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

Number of papers			Degree			Betwenness			Eigenvector		
25	Abreu,P.	IST - UTL	59	Soares,J.C.	UL	17623	Soares,J.C.	UL	0,272	Serra,F.	EURATOM IST - UTL
25	Adam,W.	AAS	53	Sousa,J.B.	UP	16804	Sousa,J.B.	UP	0,250	Manso,M.E.	EURATOM IST - UTL
25	Carvalho,M.G.	IST - UTL	49	Silva,M.F.da	ITN	12259	Conde,O.	UL	0,241	Silva,A	EURATOM IST - UTL
24	Adye,T.	RAL	44	Godinho,M.	UL	11275	Vilar,Rui	IST - UTL	0,239	Varela,P.	EURATOM IST - UTL
20	Soares,J.C.	UL	42	Serra,F.	EURATOM IST - UTL	10713	Soares,C.G.	IST - UTL	0,230	Loureiro,C.	EURATOM IST - UTL
19	Mendonca,J.T.	IST - UTL	39	Policarpo,A.J.P.L	UC	9684	Shetty,N.K.	AMC	0,223	Cupido,L.	EURATOM IST - UTL
18	Almeida,M.	ITN	37	Manso,M.E.	EURATOM IST - UTL	9017	GuedesSoares,C.	IST - UTL	0,222	Santos,J.	EURATOM IST - UTL
17	Vilar,Rui	IST - UTL	36	Varandas,C.A.F.	EURATOM IST - UTL	8780	DaSilva,M.F.	ITN	0,214	Silva,F.	UP
16	Varandas,C.A.F.	EURATOM IST - UTL	33	Fraga,M.M.F.R.	LIP-Coimbra	7908	Almeida,M.	ITN	0,207	Nunes,I.	EURATOM IST - UTL
15	Conde,C.A.N.	UC	31	Silva,A	EURATOM IST - UTL	6890	Rogalski,M.S.	IST - UTL	0,201	Kurzan,B.	EURATOM IPP

Table 103: The authors with highest number of papers, degree, betweeness and eigenvector centralities (1995-1998)

D.5. - Year 1999

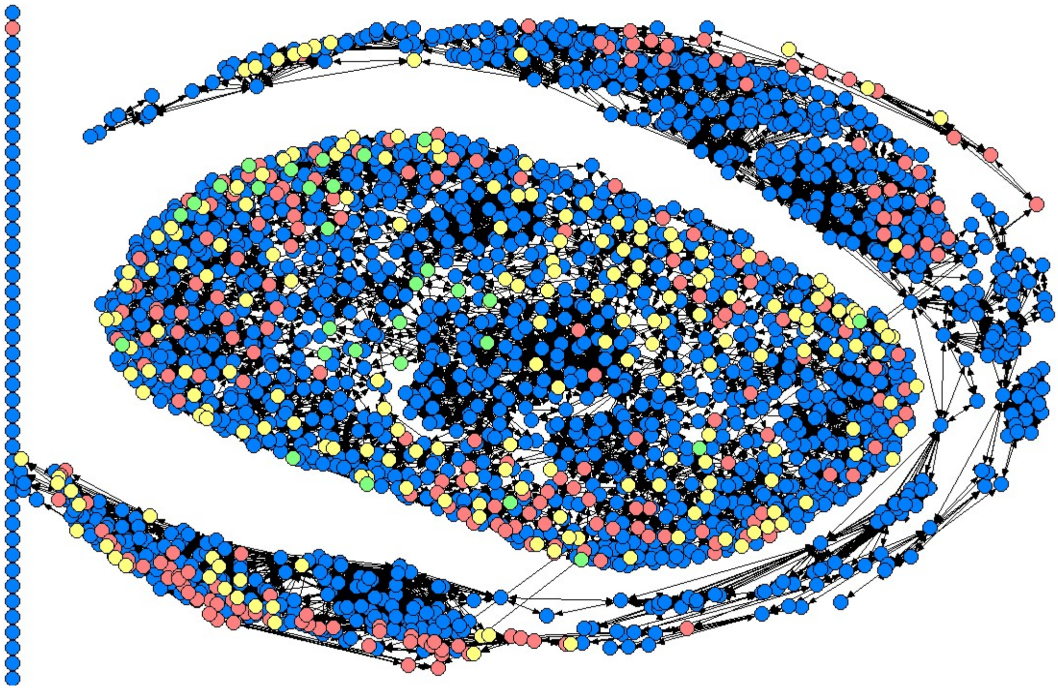


Figure 45: Energy field community co-authorship social network evolution (1995-1999) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

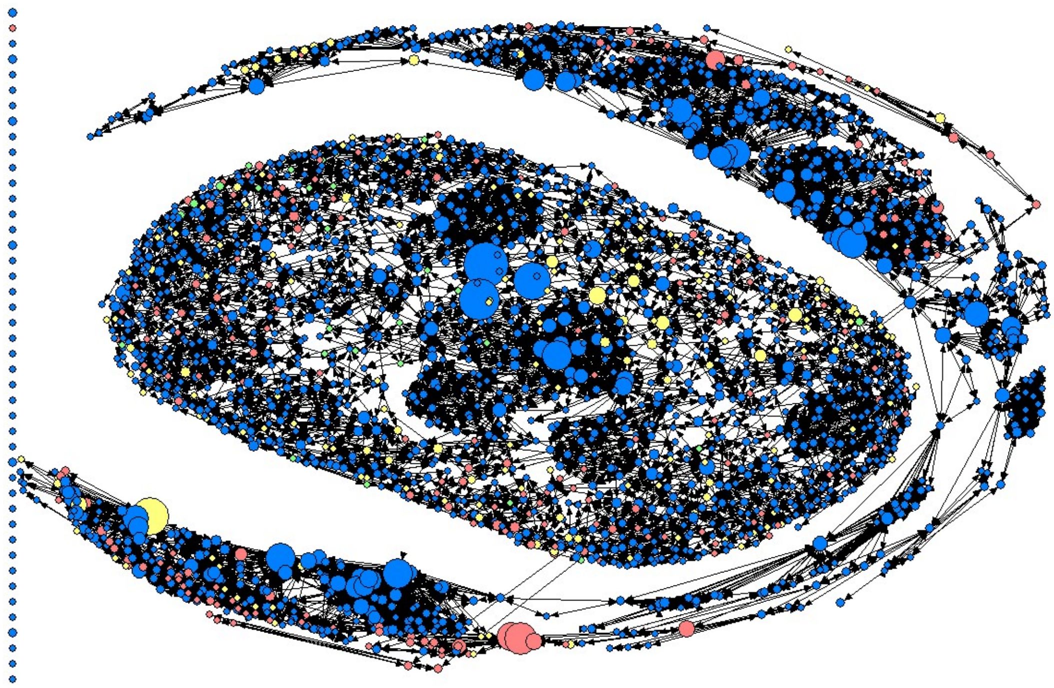


Figure 46: Number of Publications - Energy field community co-authorship social network evolution (1995-1999) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

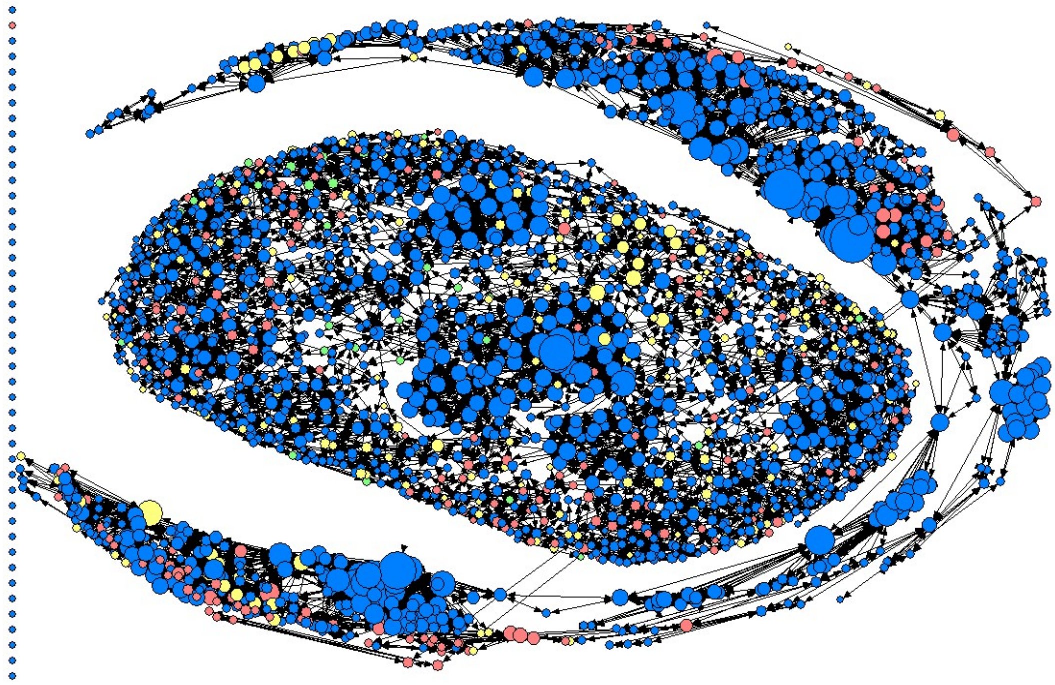


Figure 47: Degree Centrality - Energy field community co-authorship social network evolution (1995-1999) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

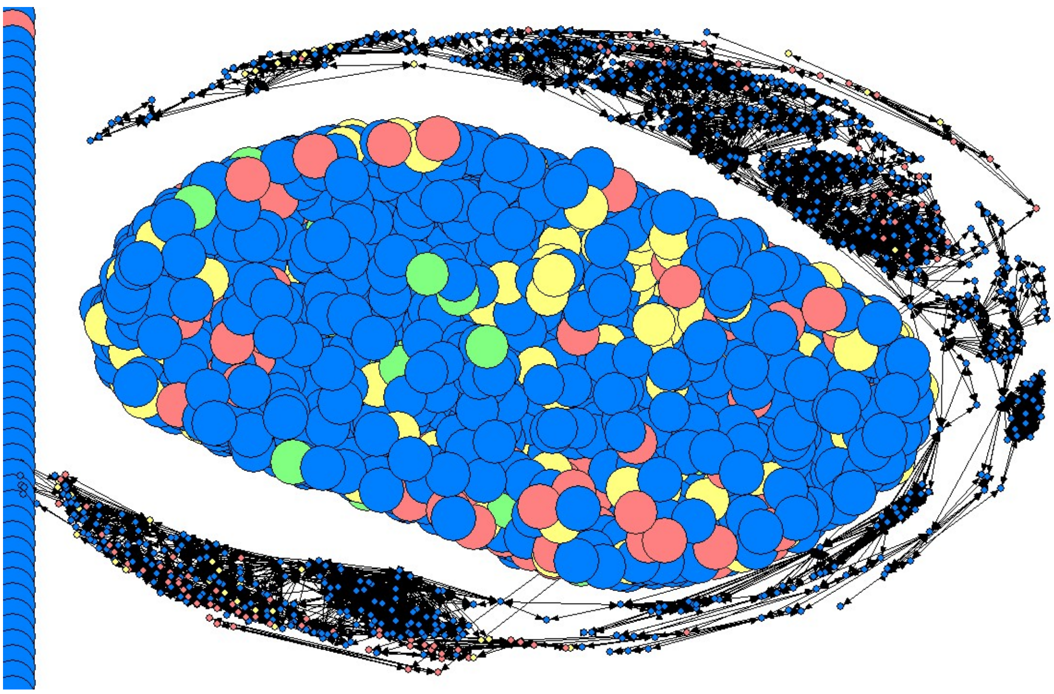


Figure 48: Closeness Centrality - Energy field community co-authorship social network evolution (1995-1999) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

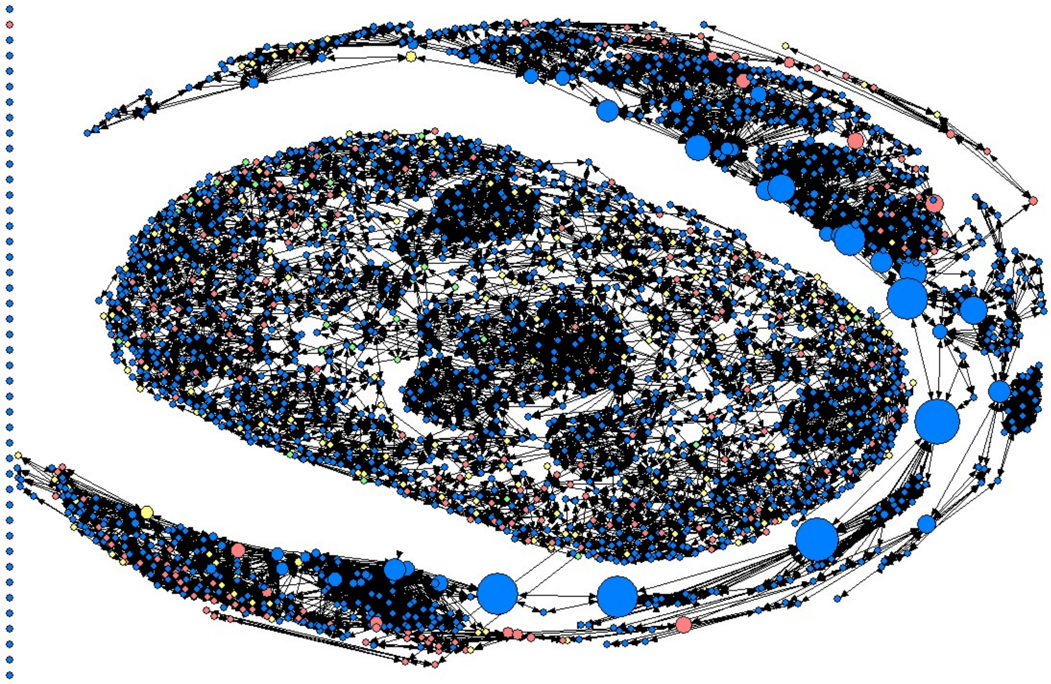


Figure 49: Betweeness Centrality - Energy field community co-authorship social network evolution (1995-1999) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

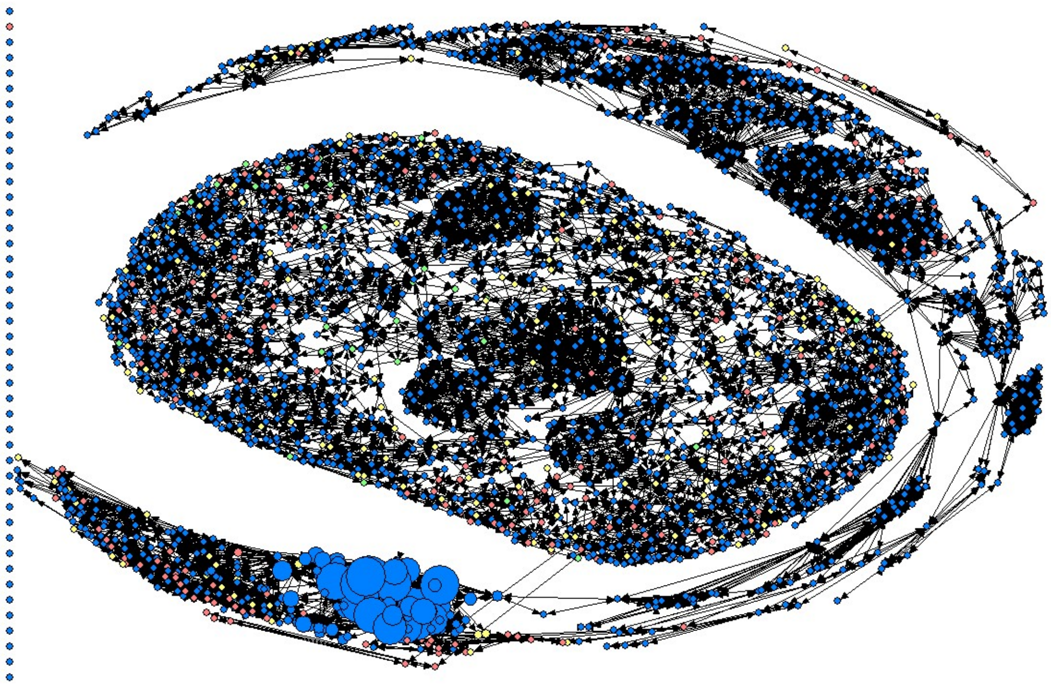


Figure 50: Eigenvector Centrality - Energy field community co-authorship social network evolution (1995-1999) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

Number of papers			Degree			Betwenness			Eigenvector		
34	Abreu,P.	IST - UTL	60	Soares,J.C.	UL	135742	Cunha,L.	UMi	0,272	Serra,F.	EURATOM IST - UTL
31	Adam,W.	AAS	55	Sousa,J.B.	UP	128082	Ribeiro,M.J.	UC	0,248	Manso,M.E.	EURATOM IST - UTL
28	Adye,T.	RAL	52	Silva,M.F.da	ITN	122657	Almeida,P.	HGO	0,239	Silva,A	EURATOM IST - UTL
28	Carvalho,M.G.	IST - UTL	48	Varandas,C.A.F.	EURATOM IST - UTL	121983	Malaquias,J.L.	UC	0,238	Varela,P.	EURATOM IST - UTL
22	Gulyurtlu,I.	INETI	46	Godinho,M.	UL	118804	Rebouta,L.	UMi	0,230	Loureiro,C.	EURATOM IST - UTL
21	Soares,J.C.	UL	44	Policarpo,A.J.P.L	UC	87955	Soares,J.C.	UL	0,221	Cupido,L.	EURATOM IST - UTL
20	Almeida,M.	ITN	42	Serra,F.	EURATOM IST - UTL	77285	Sousa,J.B.	UP	0,220	Santos,J.	EURATOM IST - UTL
20	Mendonca,J.T.	IST - UTL	37	Manso,M.E.	EURATOM IST - UTL	75250	Conde,O.	UL	0,213	Silva,F.	UP
20	Policarpo,A.J.P.L	UC	36	Amaral,V.S.	UAv	73064	Vilar,Rui	IST - UTL	0,204	Nunes,I.	EURATOM IST - UTL
20	Varandas,C.A.F.	EURATOM IST - UTL	35	Ribeiro,M.J.	UC	69078	Waerenborgh,J.C.	ITN	0,198	Kurzan,B.	EURATOM IPP

Table 104: The authors with highest number of papers, degree, betweeness and eigenvector centralities (1995-1999)

D.6. - Year 2000

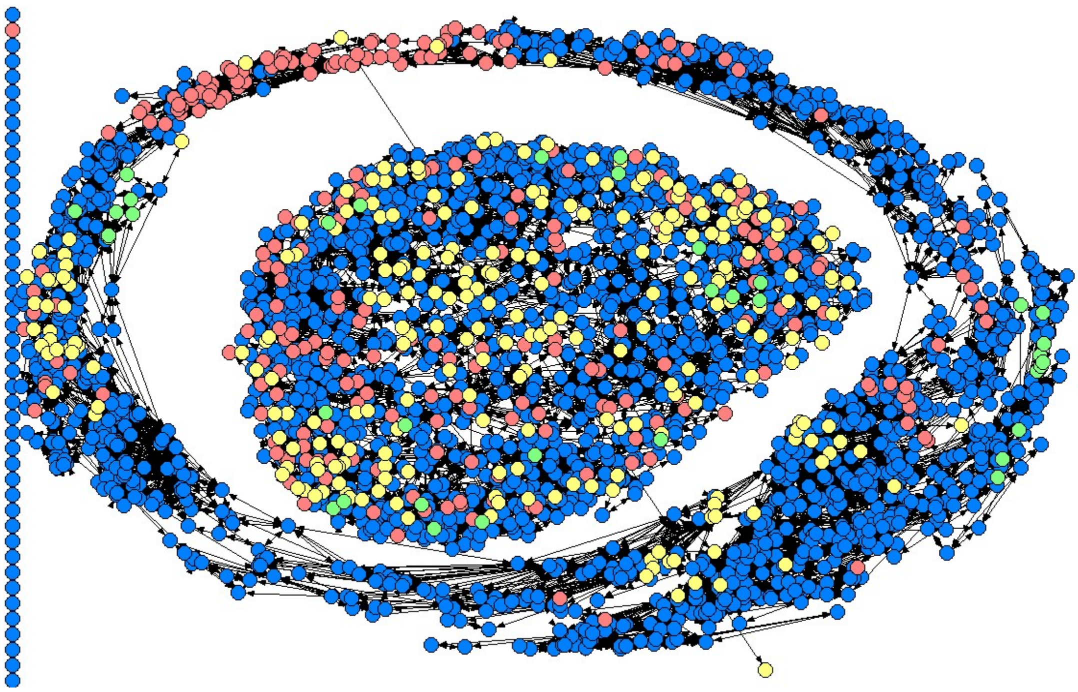


Figure 51: Energy field community co-authorship social network evolution (1995-2000) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

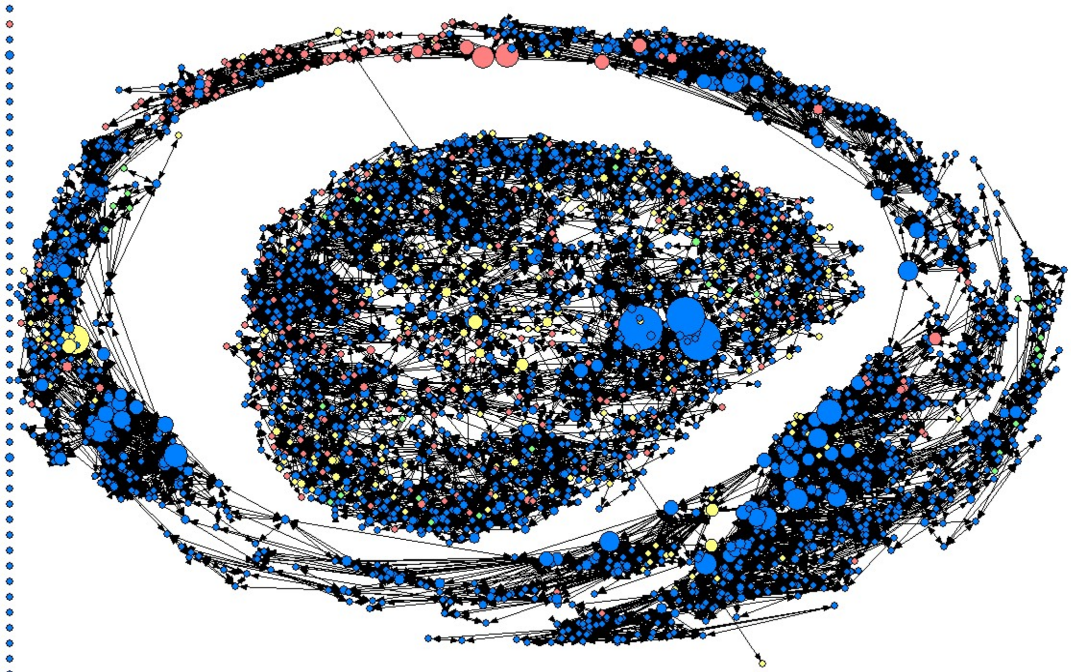


Figure 52: Number of Publications - Energy field community co-authorship social network evolution (1995-2000) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

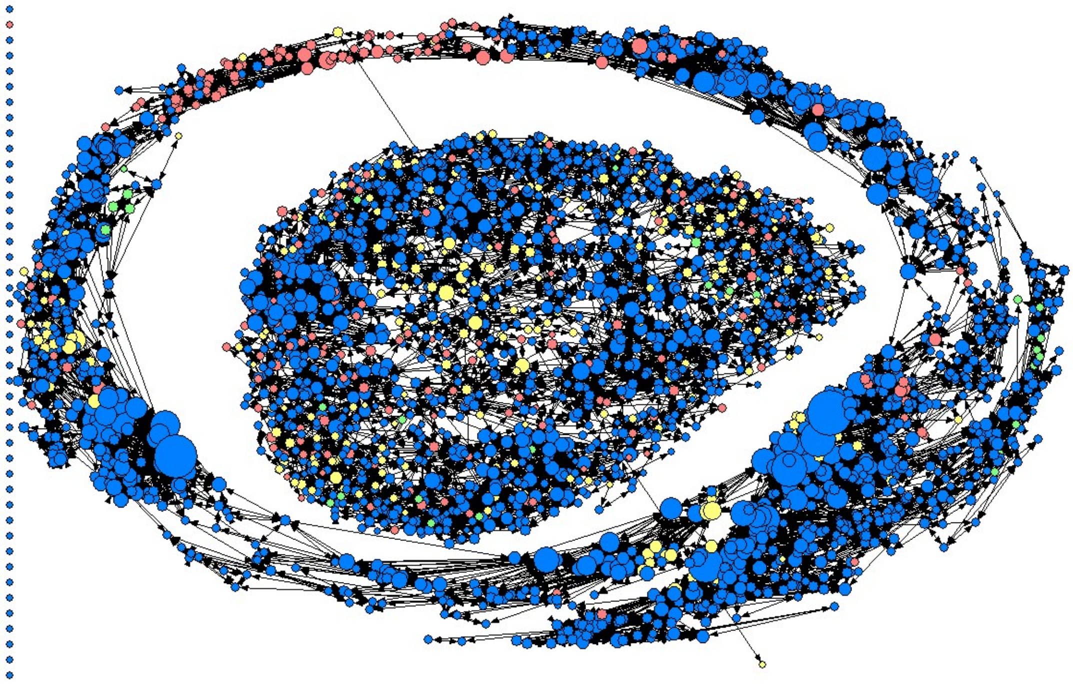


Figure 53: Degree Centrality - Energy field community co-authorship social network evolution (1995-2000) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

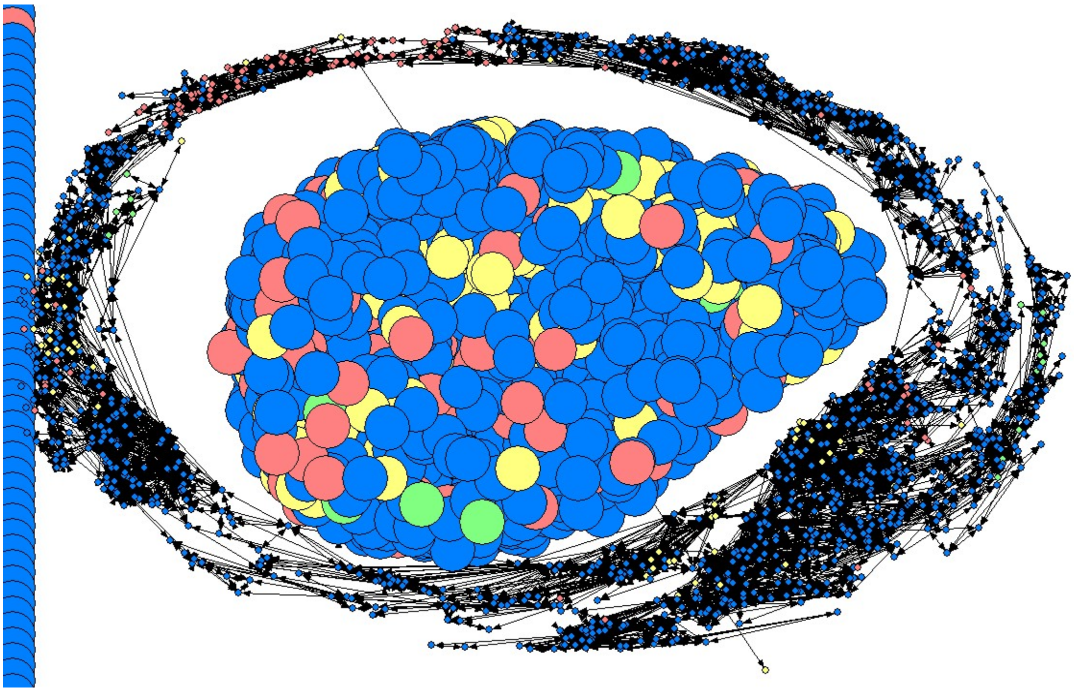


Figure 54: Closeness Centrality - Energy field community co-authorship social network evolution (1995-2000) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

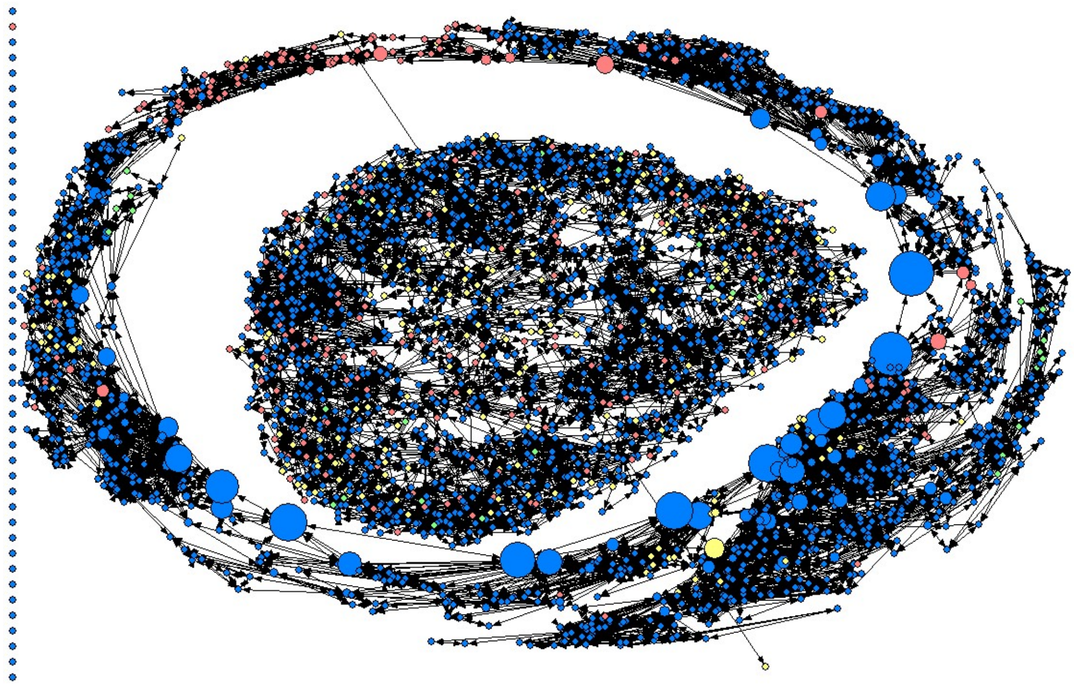


Figure 55: Betweeness Centrality - Energy field community co-authorship social network evolution (1995-2000) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

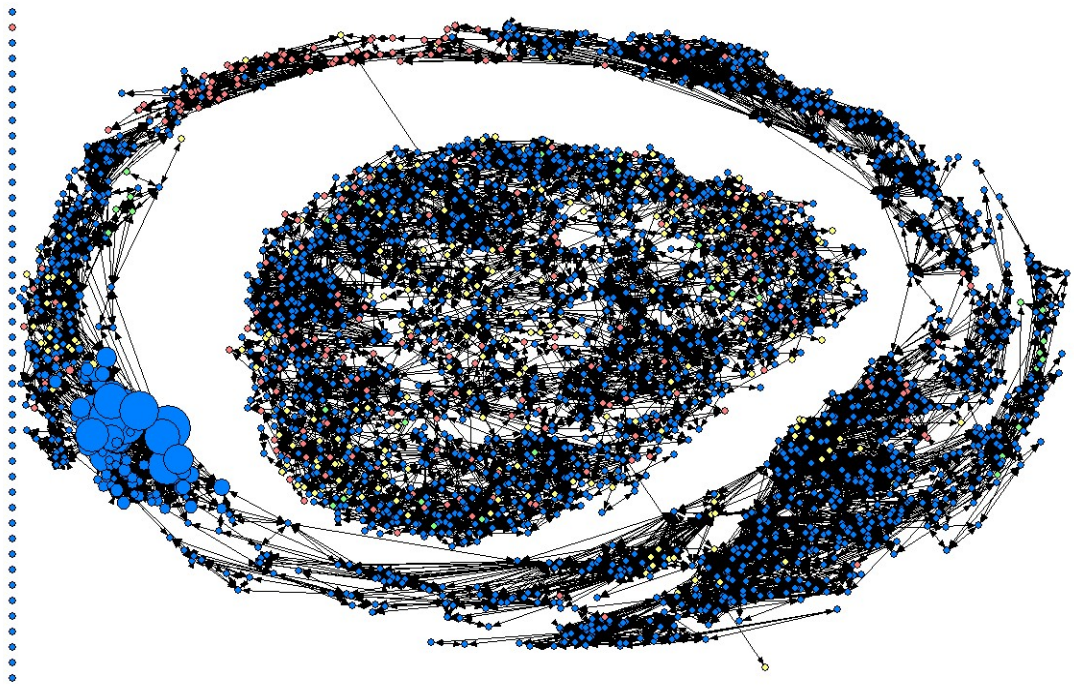


Figure 56: Eigenvector Centrality - Energy field community co-authorship social network evolution (1995-2000) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

Number of papers			Degree			Betwenness			Eigenvector		
50	Abreu,P.	IST - UTL	73	Soares,J.C.	UL	247565	Vilar,Rui	IST - UTL	0,274	Serra,F.	EURATOM IST - UTL
47	Adam,W.	AAS	70	Varandas,C.A.F.	EURATOM IST - UTL	239931	Conde,O.	UL	0,241	Manso,M.E.	EURATOM IST - UTL
43	Adye,T.	RAL	56	Sousa,J.B.	UP	199109	Goncalves,I.F.	ITN	0,231	Varela,P.	EURATOM IST - UTL
30	Carvalho,M.G.	IST - UTL	55	Godinho,M.	UL	194949	Marques,J.G.	ITN	0,231	Silva,A	EURATOM IST - UTL
25	Soares,J.C.	UL	53	Silva,M.F.da	ITN	192233	Branquinho,Cristina	UL	0,224	Loureiro,C.	EURATOM IST - UTL
24	Almeida,M.	ITN	45	Serra,F.	EURATOM IST - UTL	189152	Cruz,C.	ITN	0,213	Santos,J.	EURATOM IST - UTL
24	Gulyurtlu,I.	INETI	44	Policarpo,A.J.P.L	UC	177574	Soares,A.	EURATOM IST - UTL	0,213	Cupido,L.	EURATOM IST - UTL
23	Varandas,C.A.F.	EURATOM IST - UTL	43	Almeida,M.	ITN	150958	Almeida,A.	IST - UTL	0,211	Silva,F.	UP
22	Mendonca,J.T.	IST - UTL	42	Alves,E.	ITN	141517	Alves,E.	ITN	0,199	Kurzan,B.	EURATOM IPP

Table 105: The authors with highest number of papers, degree, betweeness and eigenvector centralities (1995-2000)

D.7. - Year 2001

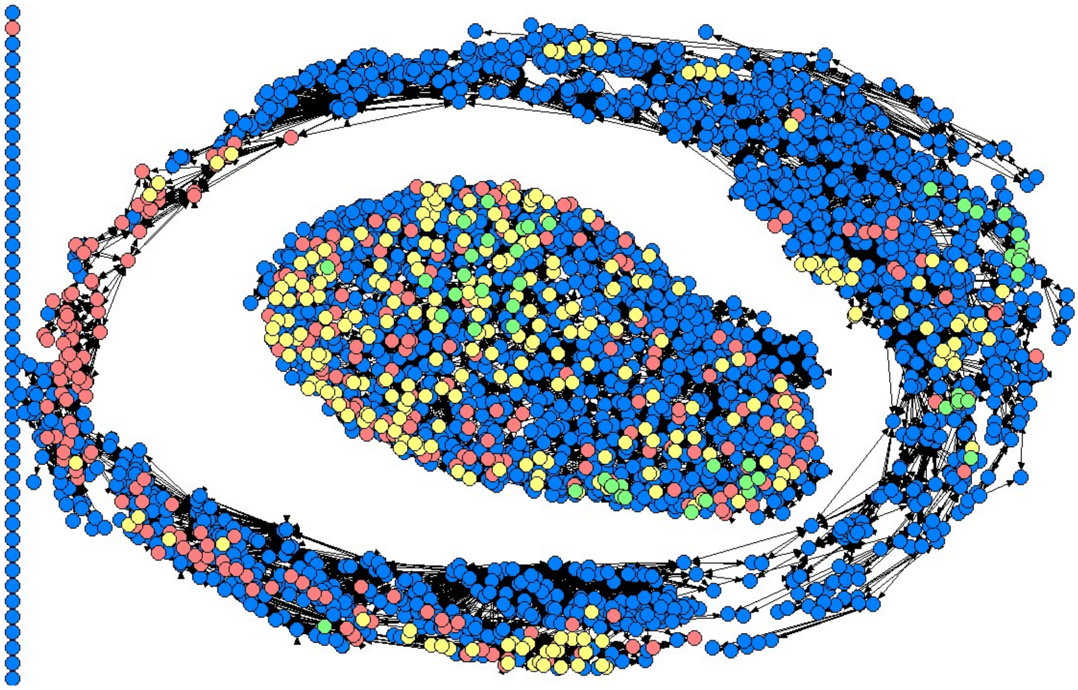


Figure 57: Energy field community co-authorship social network evolution (1995-2001) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

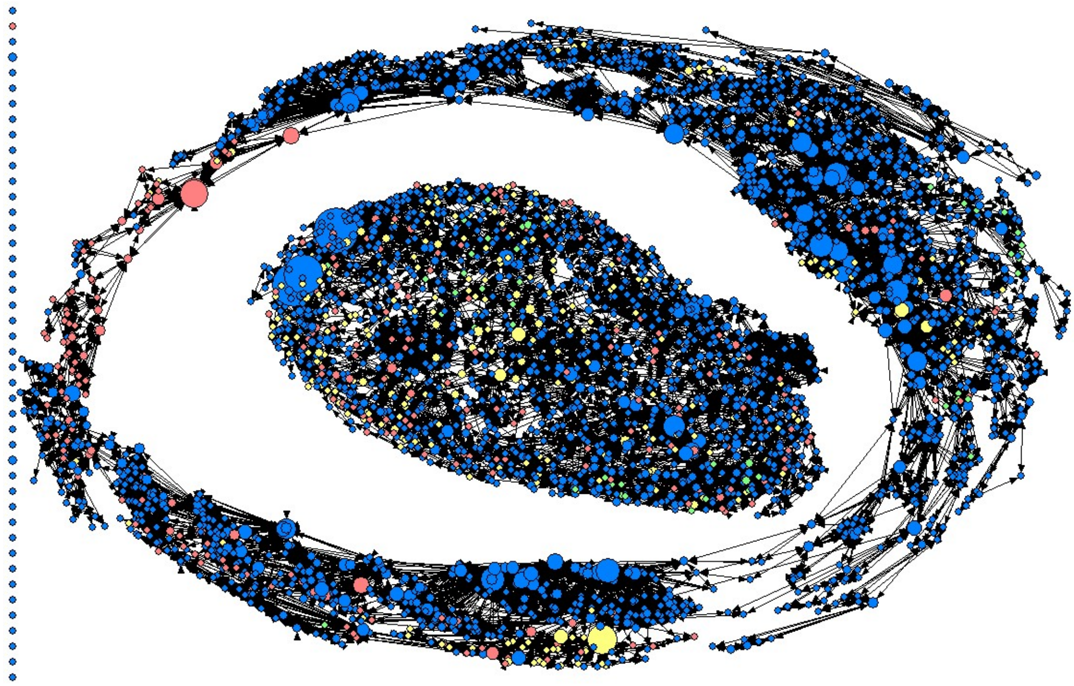


Figure 58: Number of Publications - Energy field community co-authorship social network evolution (1995-2001) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

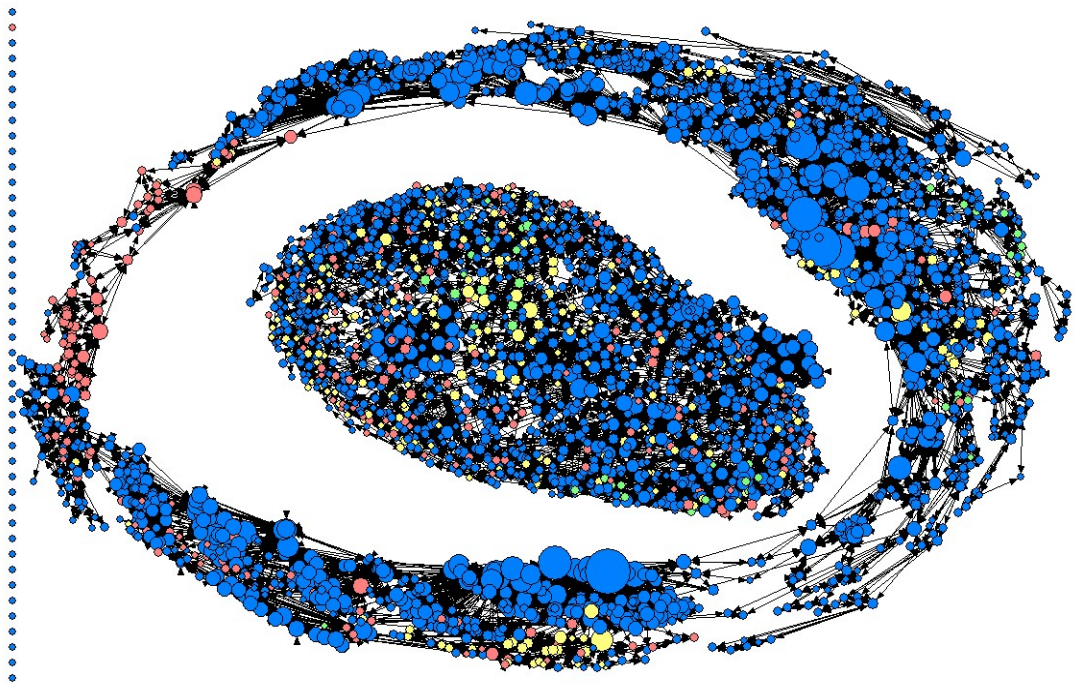


Figure 59: Degree Centrality - Energy field community co-authorship social network evolution (1995-2001) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

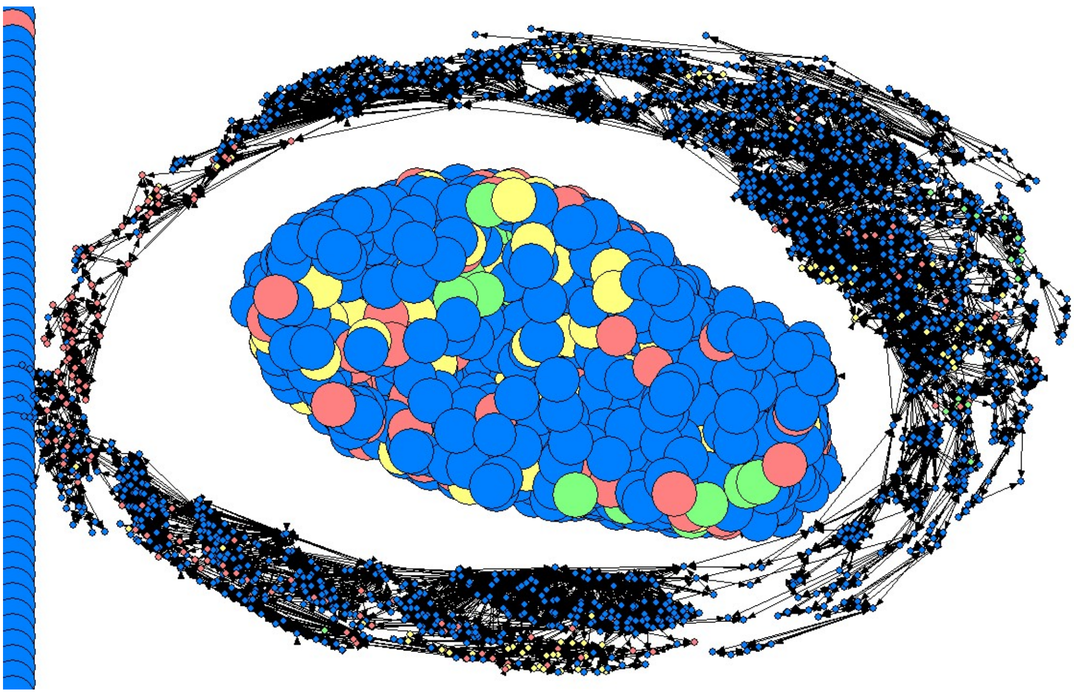


Figure 60: Closeness Centrality - Energy field community co-authorship social network evolution (1995-2001) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

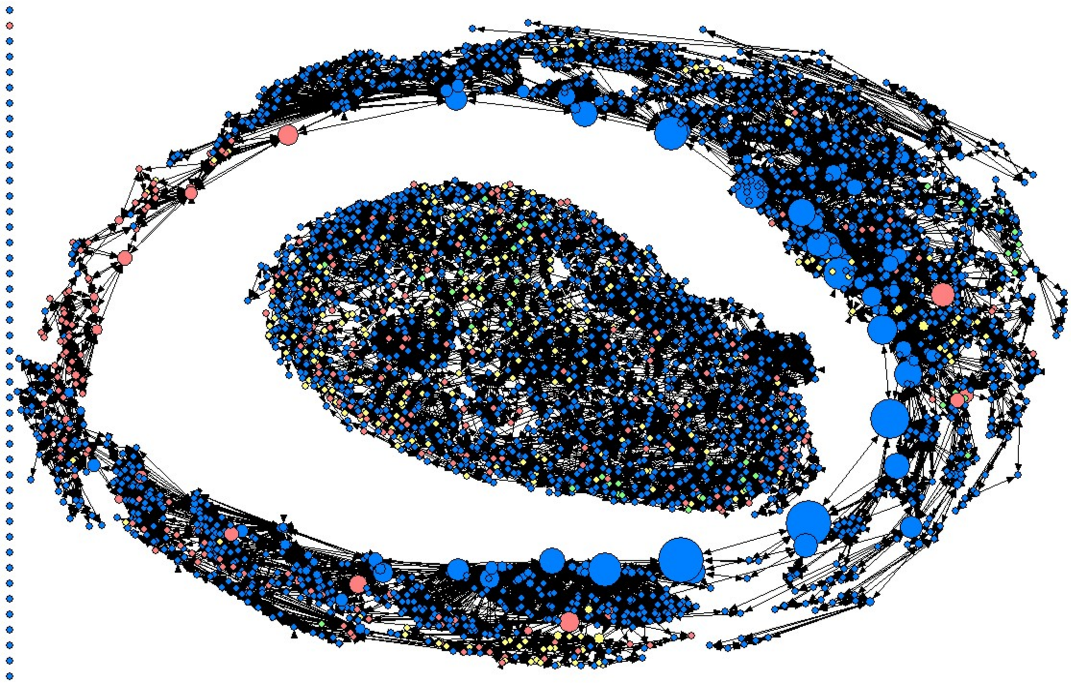


Figure 61: Centrality - Energy field community co-authorship social network evolution (1995-2001) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

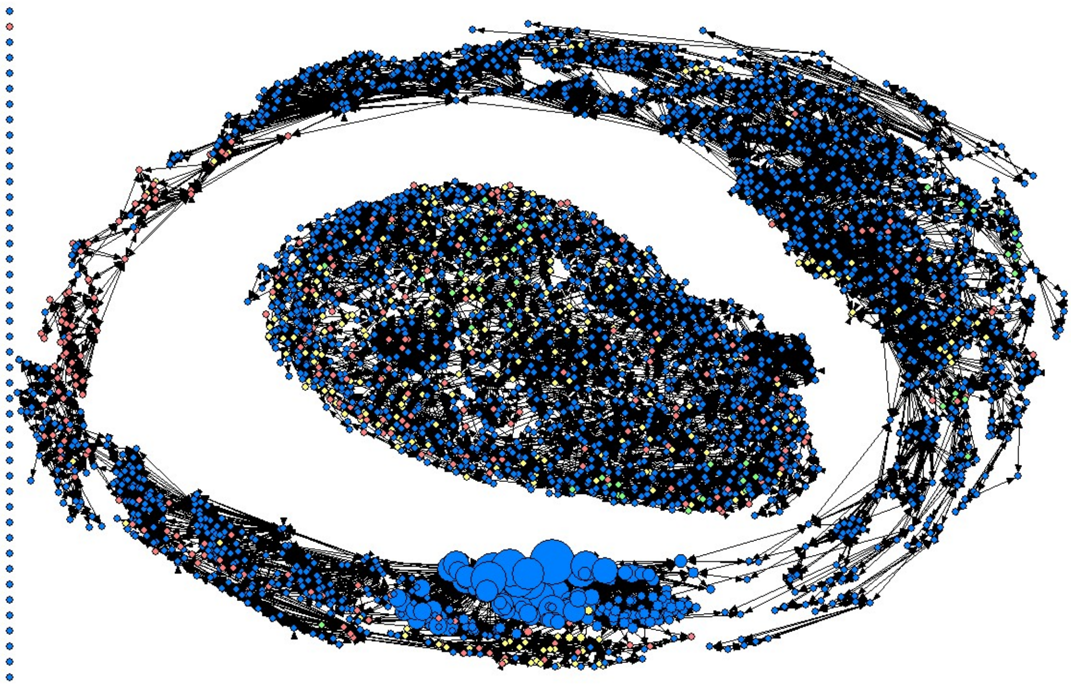


Figure 62: Eigenvector Centrality - Energy field community co-authorship social network evolution (1995-2001) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

Number of papers			Degree			Betwenness			Eigenvector		
56	Abreu,P.	IST - UTL	83	Varandas,C.A.F.	EURATOM IST - UTL	391759	Branquinho,Cristina	UL	0,275	Serra,F.	EURATOM IST - UTL
53	Adam,W.	AAS	73	Soares,J.C.	UL	389021	Soares,A.	EURATOM IST - UTL	0,255	Kurzan,B.	EURATOM IPP
48	Adye,T.	RAL	62	Sousa,J.B.	UP	324454	Cruz,C.	ITN	0,225	Manso,M.E.	EURATOM IST - UTL
33	Carvalho,M.G.	IST - UTL	61	Silva,M.F.da	ITN	281790	Varandas,C.A.F.	EURATOM IST - UTL	0,214	Suttrop,W.	EURATOM IPP
30	Gulyurtlu,I.	INETI	60	Serra,F.	EURATOM IST - UTL	277816	Vilar,Rui	IST - UTL	0,208	Vergamota,S.	EURATOM IST - UTL
27	Varandas,C.A.F.	EURATOM IST - UTL	57	Alves,E.	ITN	270487	Conde,O.	UL	0,186	Silva,A	EURATOM IST - UTL
26	Mendonca,J.T.	IST - UTL	55	Godinho,M.	UL	258920	Marques,J.G.	ITN	0,184	Varela,P.	EURATOM IST - UTL
25	Cabrita,I.	INETI	48	Manso,M.E.	EURATOM IST - UTL	238197	Goncalves,I.F.	ITN	0,174	Loureiro,C.	EURATOM IST - UTL
25	Freitas,M.C.	ITN	48	Kurzan,B.	EURATOM IPP	219484	Sousa,J.B.	UP	0,173	Cupido,L.	EURATOM IST - UTL
25	Soares,J.C.	UL	44	Policarpo,A.J.P.L	UC	213924	Cunha,L.	UMi	0,166	Santos,J.	EURATOM IST - UTL

Table 106: The authors with highest number of papers, degree, betweeness and eigenvector centralities (1995-2001)

D.8. - Year 2002

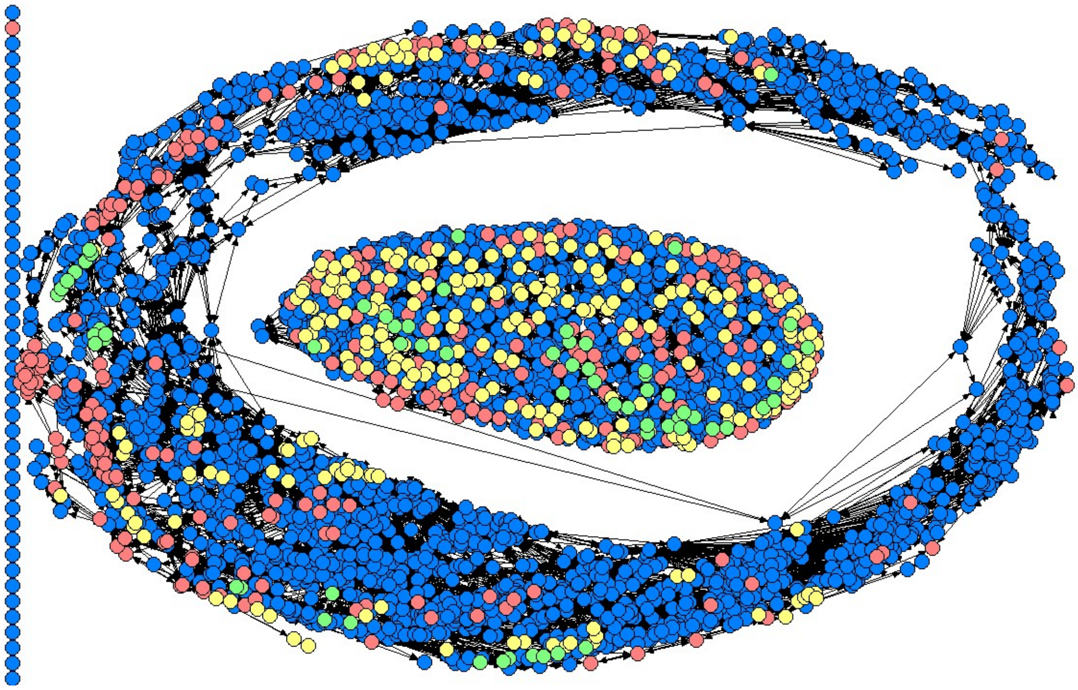


Figure 63: Energy field community co-authorship social network evolution (1995-2002) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

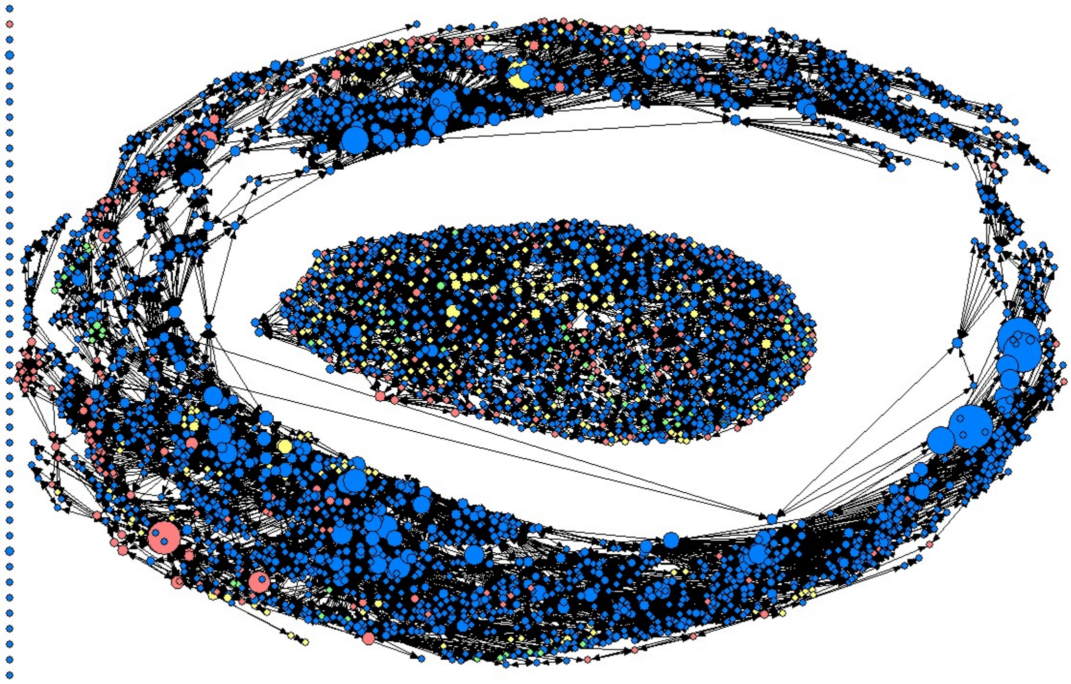


Figure 64: Number of Publications - Energy field community co-authorship social network evolution (1995-2002) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

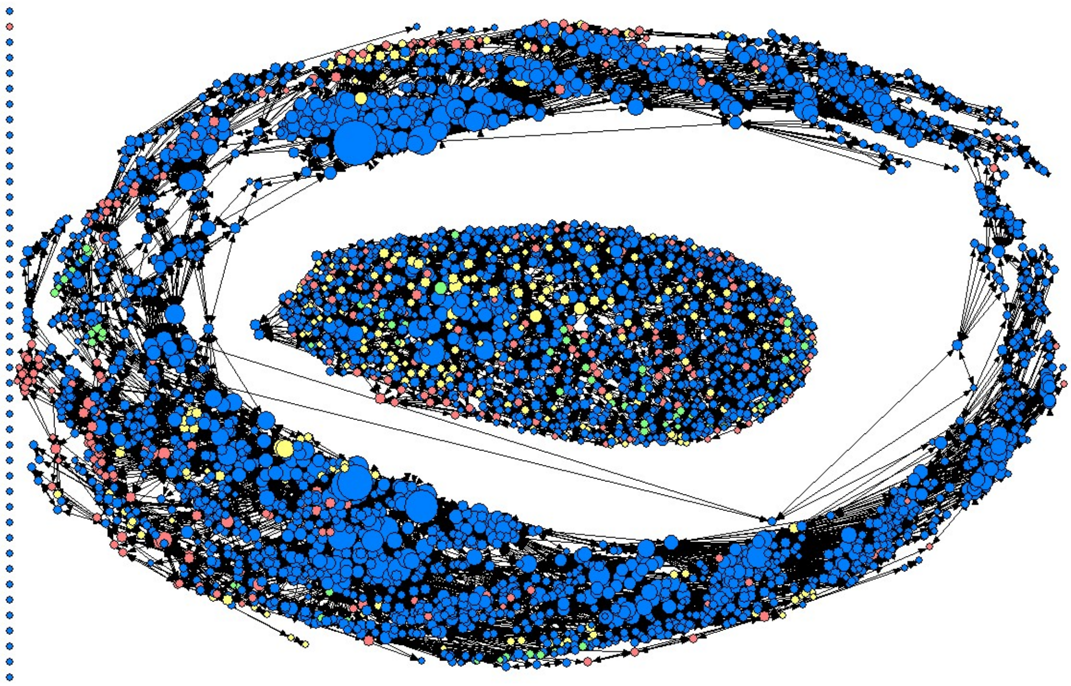


Figure 65: Degree Centrality - Energy field community co-authorship social network evolution (1995-2002) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

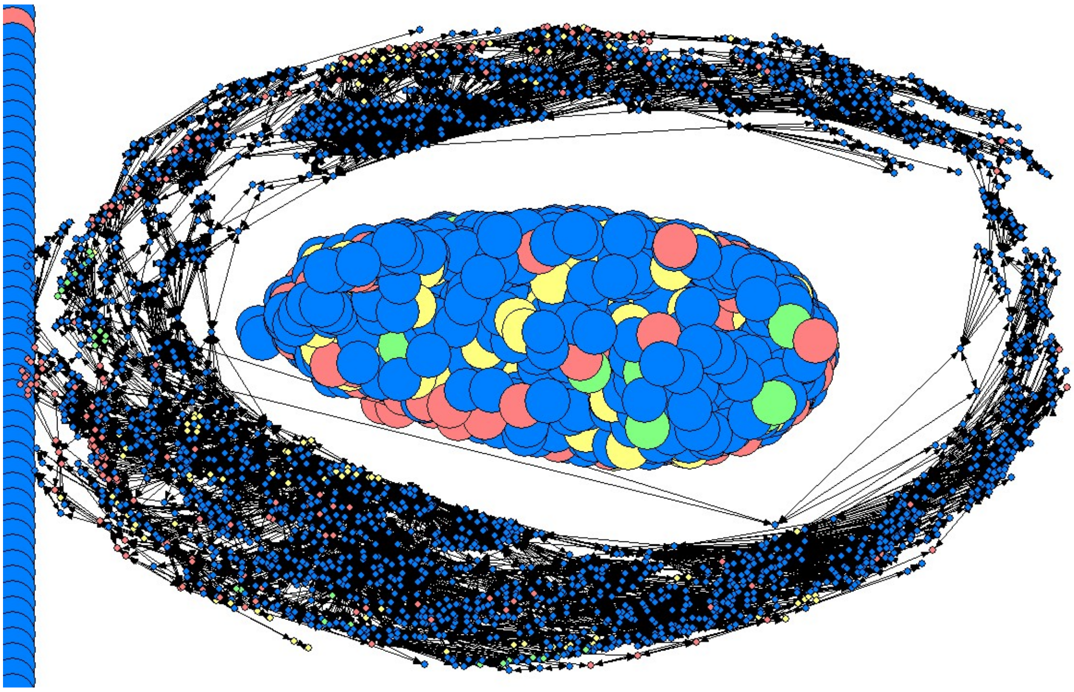


Figure 66: Closeness Centrality - Energy field community co-authorship social network evolution (1995-2002) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

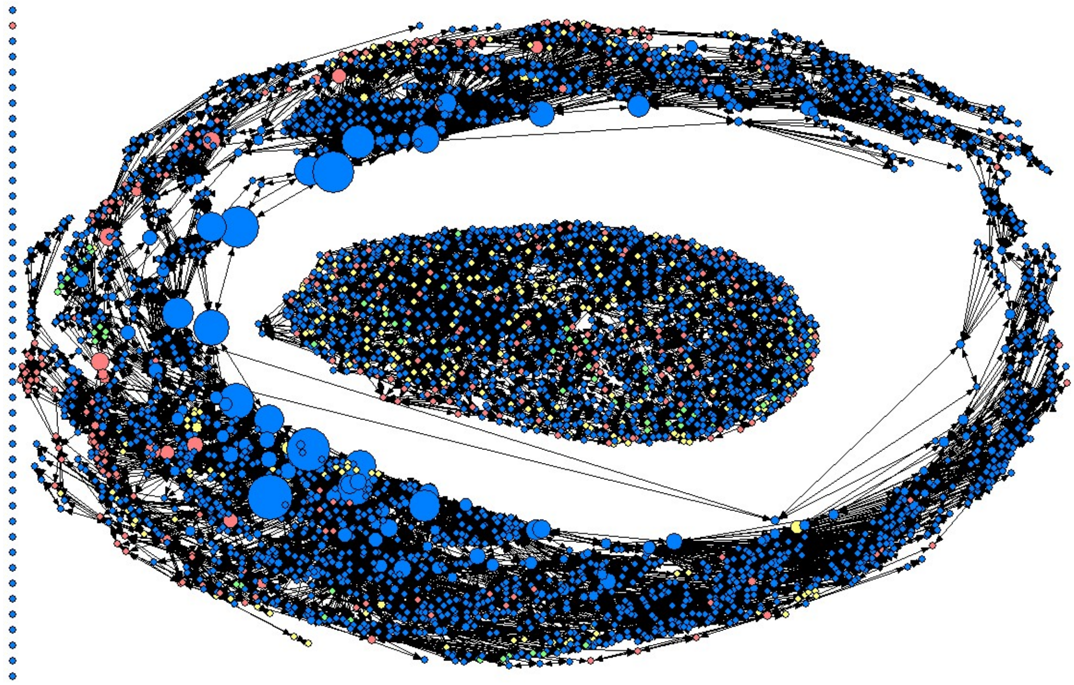


Figure 67: Betweeness Centrality - Energy field community co-authorship social network evolution (1995-2002) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

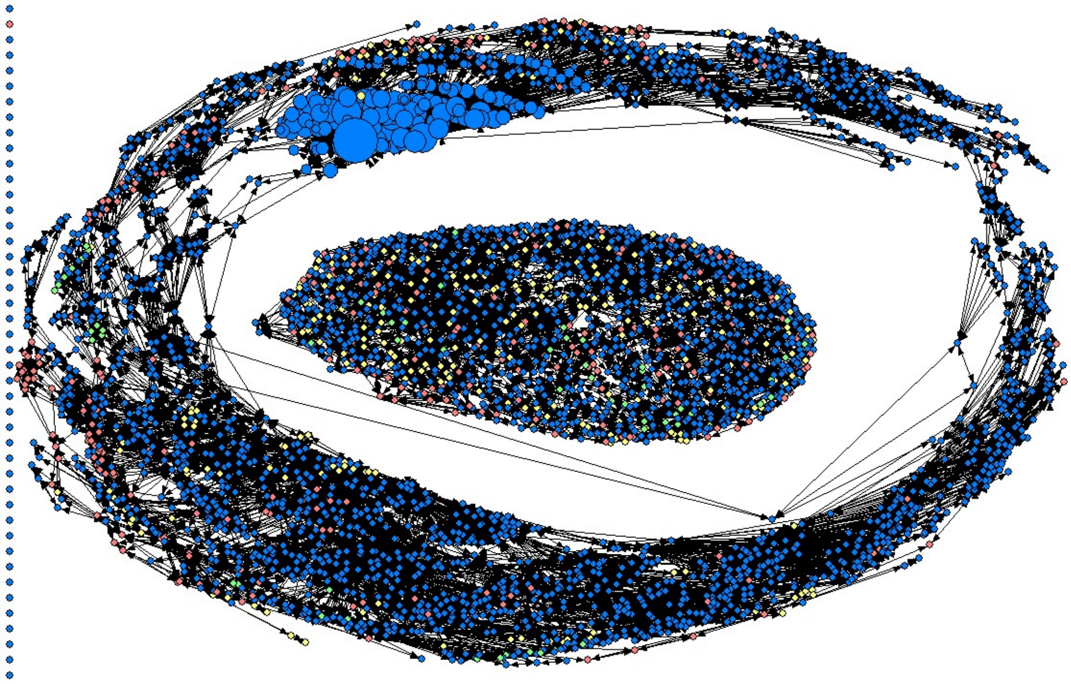


Figure 68: Eigenvector Centrality - Energy field community co-authorship social network evolution (1995-2002) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

Number of papers			Degree			Betwenness			Eigenvector		
57	Abreu,P.	IST - UTL	100	Varandas,C.A.F.	EURATOM IST - UTL	555491	Teixeira,V.	UMi	0,309	Varandas,C.A.F.	EURATOM IST - UTL
54	Adam,W.	AAS	75	Soares,J.C.	UL	531141	Rebouta,L.	UMi	0,192	Hidalgo,C.	EURATOM CIEMAT
48	Adye,T.	RAL	69	Alves,E.	ITN	499047	Branquinho,Cristina	UL	0,191	Pedrosa,M.A.	EURATOM CIEMAT
41	Gulyurtlu,I.	INETI	68	Sousa,J.B.	UP	494289	Soares,A.	EURATOM IST - UTL	0,180	Serra,F.	EURATOM IST - UTL
36	Cabrita,I.	INETI	63	Silva,M.F.da	ITN	425302	Cunha,L.	UMi	0,169	Fernandes,H.	EURATOM IST - UTL
34	Carvalho,M.G.	IST - UTL	61	Godinho,M.	UL	423559	Cruz,C.	ITN	0,157	Cabral,J.A.C.	EURATOM IST - UTL
33	Mendonca,J.T.	IST - UTL	60	Serra,F.	EURATOM IST - UTL	415118	Alves,E.	ITN	0,143	Manso,M.E.	EURATOM IST - UTL
33	Varandas,C.A.F.	EURATOM IST - UTL	52	Nave,M.F.F.	EURATOM IST - UTL	402521	Varandas,C.A.F.	EURATOM IST - UTL	0,140	Malaquias,A.	EURATOM IST - UTL
31	Providencia,J.da	UC	49	Manso,M.E.	EURATOM IST - UTL	369834	Marques,J.G.	ITN	0,139	Nedzelskij,I.S.	EURATOM IST - UTL
26	Almeida,M.	ITN	48	Almeida,M.	ITN	360743	Ribeiro,M.J.	UC	0,135	Chmyga,A.A.	IPP

Table 107: The authors with highest number of papers, degree, betweeness and eigenvector centralities (1995-2002)

D.9. - Year 2003

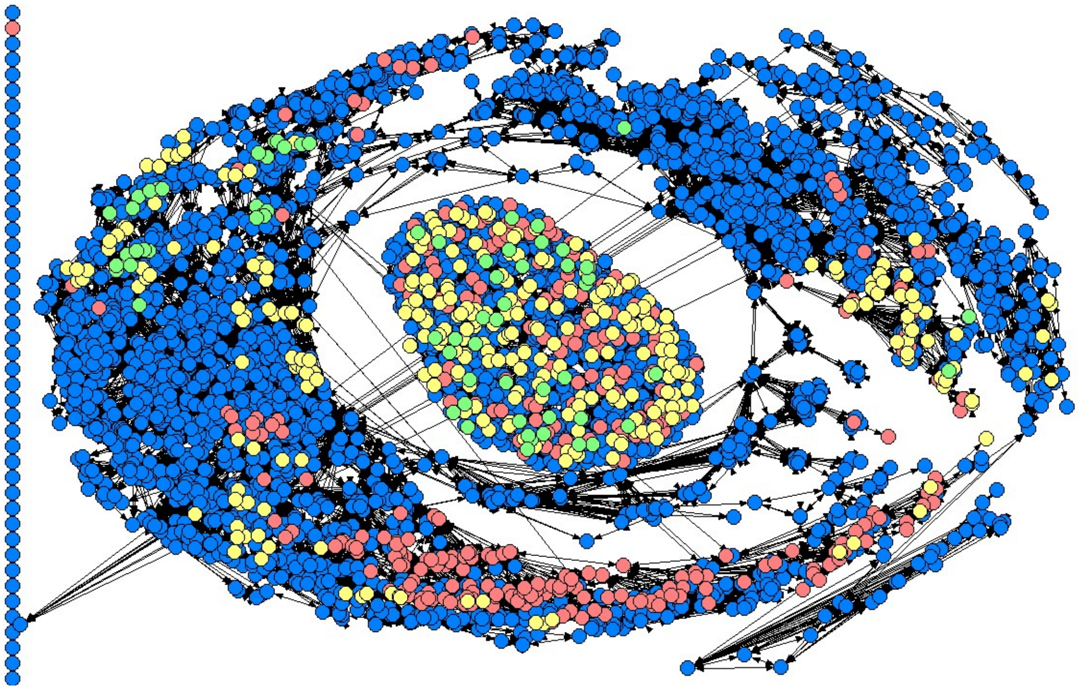


Figure 69: Energy field community co-authorship social network evolution (1995-2003) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

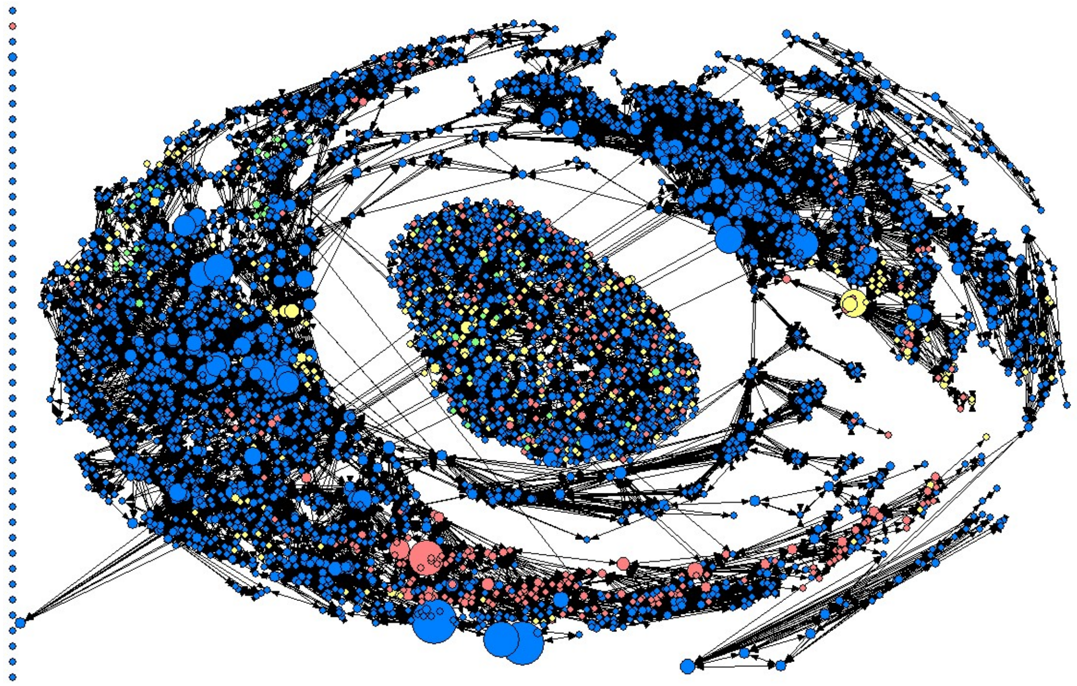


Figure 70: Number of Publications - Energy field community co-authorship social network evolution (1995-2003) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

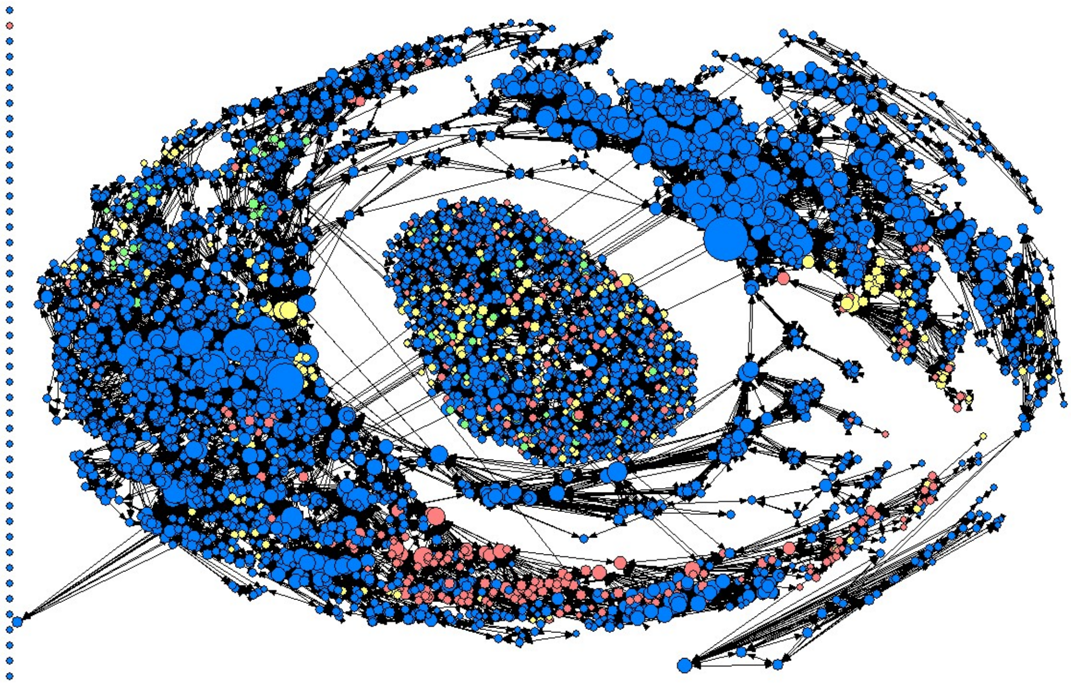


Figure 71: Degree Centrality - Energy field community co-authorship social network evolution (1995-2003) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

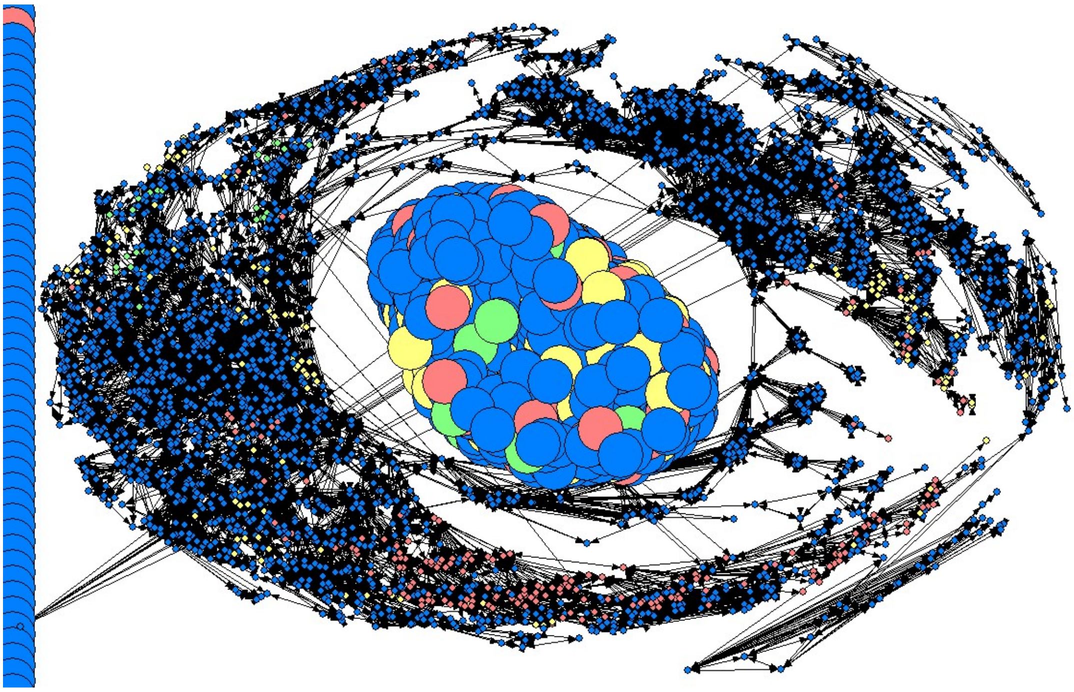


Figure 72: Closeness Centrality - Energy field community co-authorship social network evolution (1995-2003) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

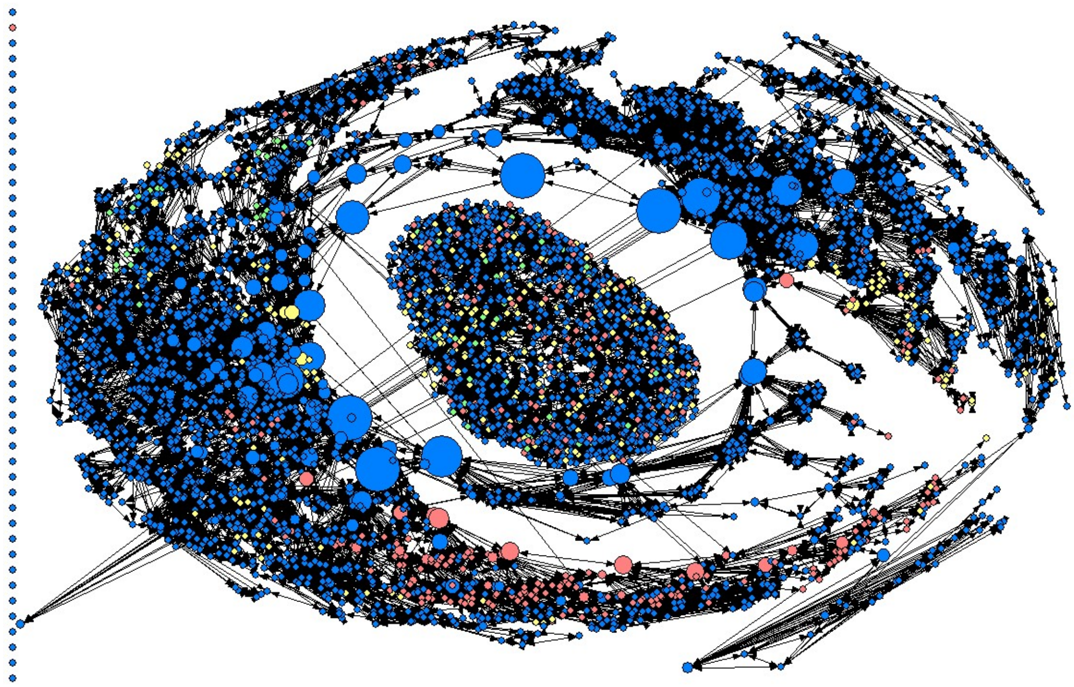


Figure 73: Betweeness Centrality - Energy field community co-authorship social network evolution (1995-2003) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

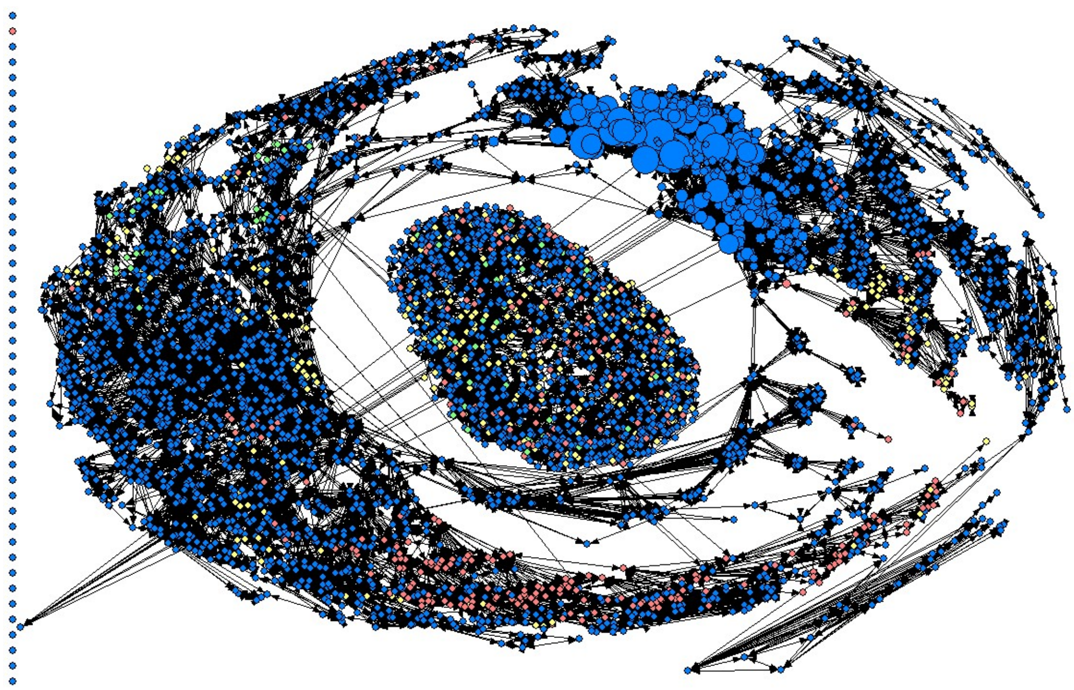


Figure 74: Eigenvector Centrality - Energy field community co-authorship social network evolution (1995-2003) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

Number of papers			Degree			Betwenness			Eigenvector		
65	Abreu,P.	IST - UTL	100	Varandas,C.A.F.	EURATOM IST - UTL	692084	Rebouta,L.	UMi	0,249	Mantsinen,M.J.	EURATOM TEKES
62	Adam,W.	AAS	83	Nave,M.F.F.	EURATOM IST - UTL	687312	Teixeira,V.	UMi	0,224	Joffrin,E.	EURATOM CEA
50	Gulyurtlu,I.	INETI	81	Soares,J.C.	UL	683840	Branquinho,Cristina	UL	0,197	Nave,M.F.F.	EURATOM IST - UTL
48	Adye,T.	RAL	80	Alves,E.	ITN	679678	Soares,A.	EURATOM IST - UTL	0,194	Noterdaeme,J.M.	EURATOM IPP
45	Cabrita,I.	INETI	71	Sousa,J.B.	UP	609019	Cunha,L.	UMi	0,177	Litaudon,X.	EURATOM CEA
40	Freitas,M.C.	ITN	66	Serra,F.	EURATOM IST - UTL	590704	Serra,F.	EURATOM IST - UTL	0,156	Sauter,O.	EURATOM Suisse
40	Mendonca,J.T.	IST - UTL	66	Mantsinen,M.J.	EURATOM TEKES	567592	Varandas,C.A.F.	EURATOM IST - UTL	0,155	Pericoli,V.	EURATOM ENEA
39	Providencia,J.da	UC	63	Silva,M.F.da	ITN	542509	Alves,E.	ITN	0,155	Tuccillo,A.A.	EURATOM ENEA
37	Varandas,C.A.F.	EURATOM IST - UTL	61	Godinho,M.	UL	475983	Cruz,C.	ITN	0,143	Baar,M.de	EURATOM FOM
36	Carvalho,M.G.	IST - UTL	57	Amaral,V.S.	UAv	454070	Nunes,F.D.	EURATOM IST - UTL	0,143	Felton,R.	EURATOM UKAEA

Table 108: The authors with highest number of papers, degree, betweeness and eigenvector centralities (1995-2003)

D.10. - Year 2004

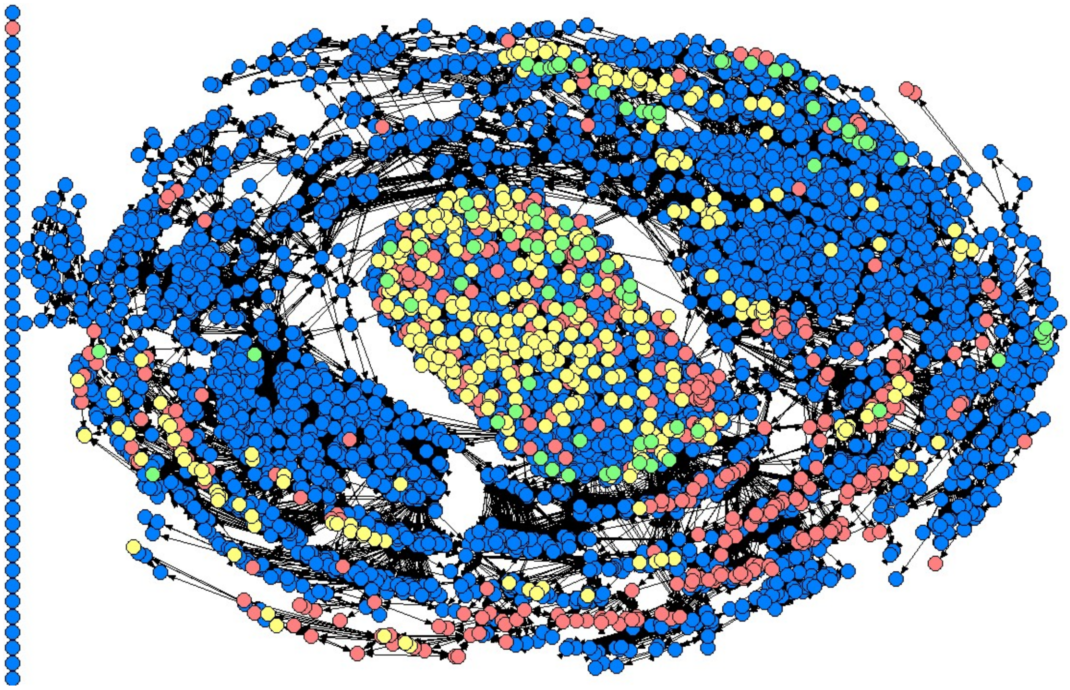


Figure 75: Energy field community co-authorship social network evolution (1995-2004) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

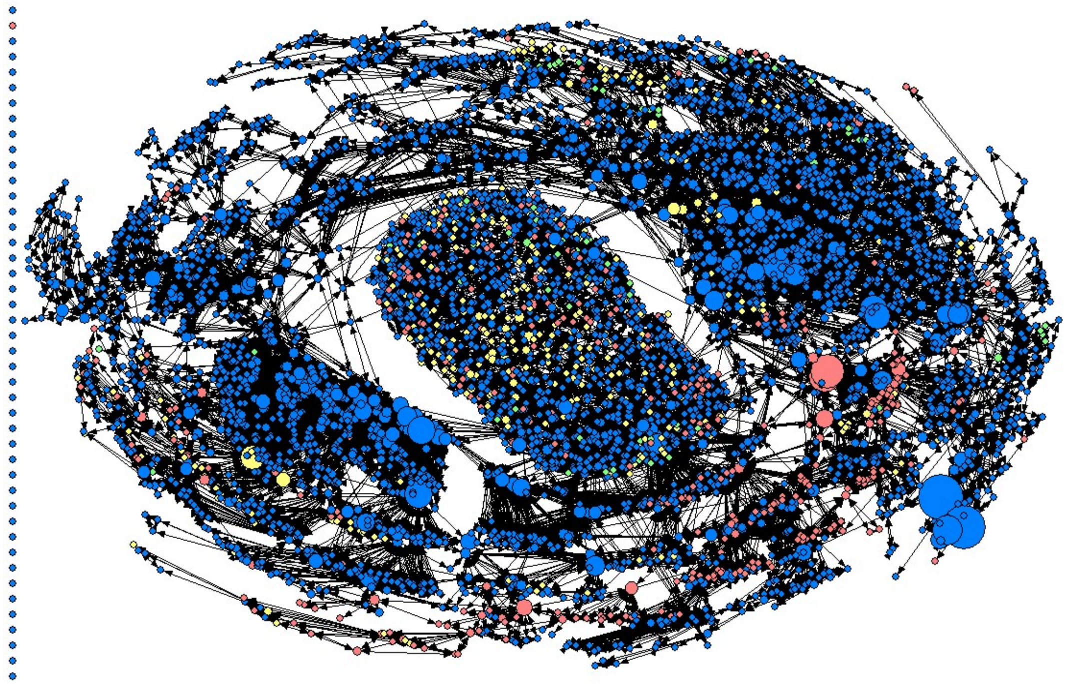


Figure 76: Number of Publications - Energy field community co-authorship social network evolution (1995-2004) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

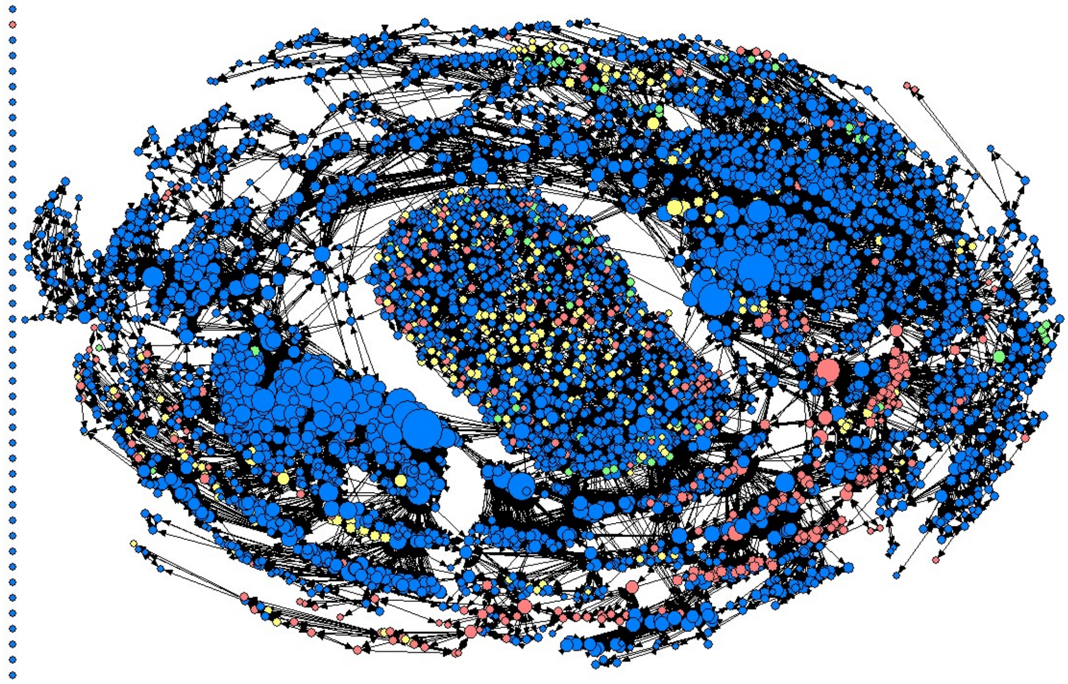


Figure 77: Degree Centrality - Energy field community co-authorship social network evolution (1995-2004) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

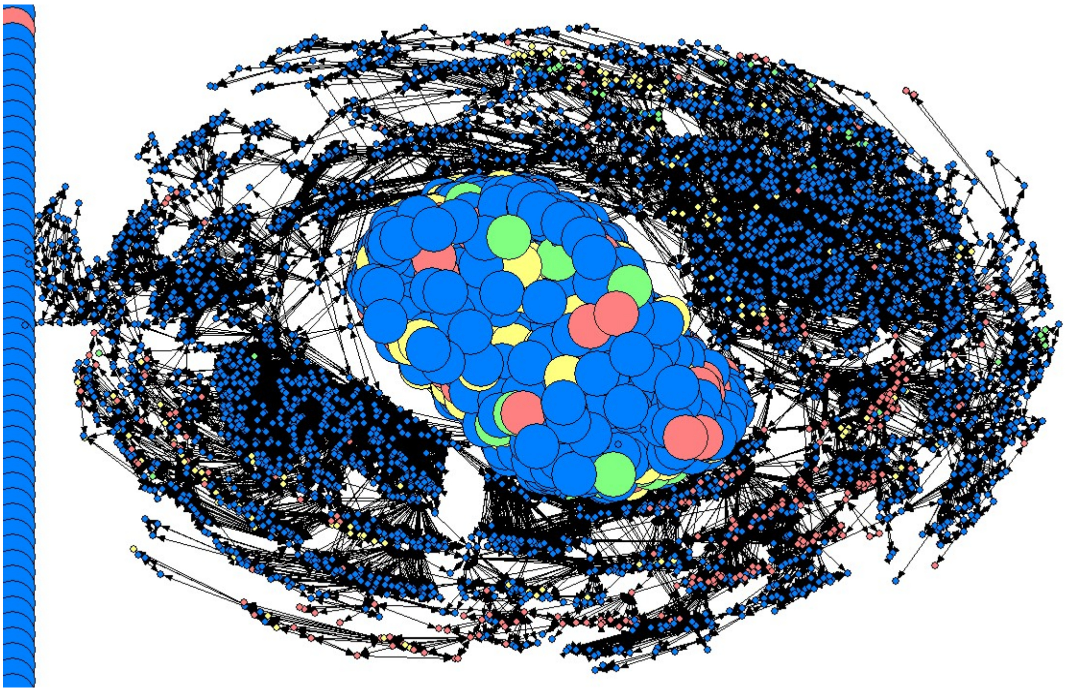


Figure 78: Closeness Centrality - Energy field community co-authorship social network evolution (1995-2004) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

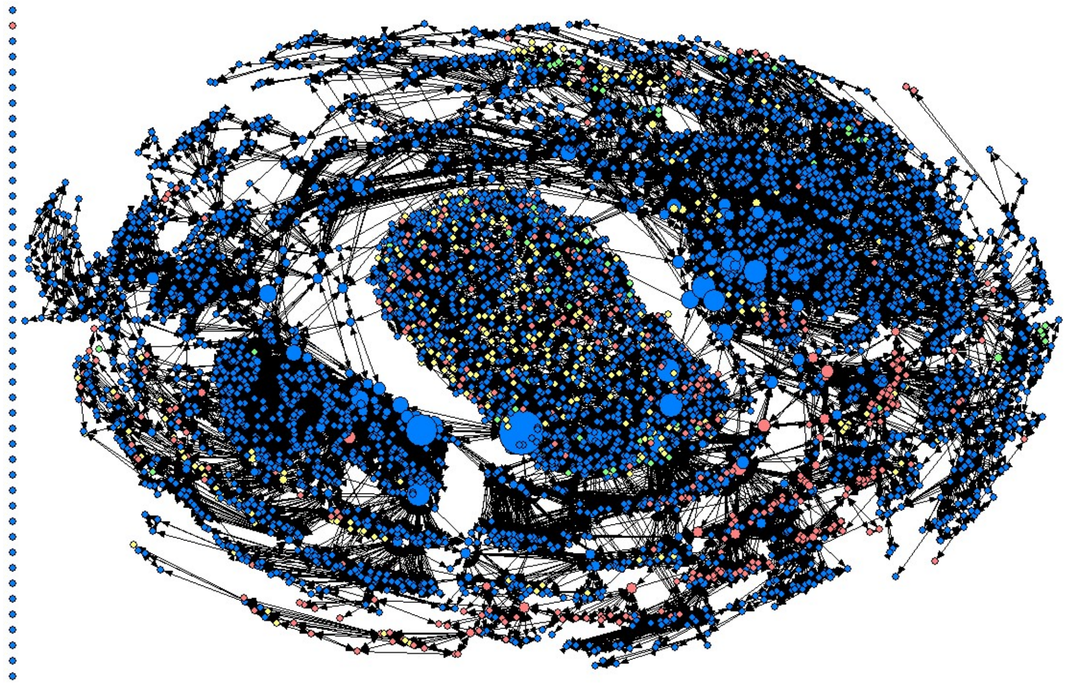


Figure 79: Betweeness Centrality - Energy field community co-authorship social network evolution (1995-2004) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

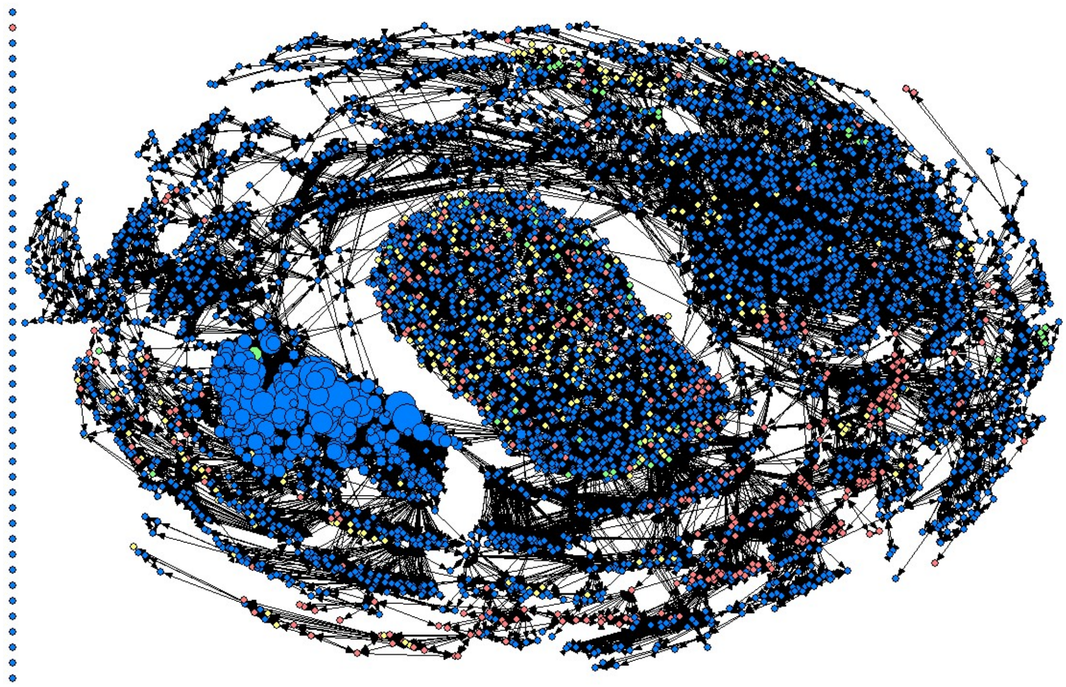


Figure 80: Eigenvector Centrality - Energy field community co-authorship social network evolution (1995-2004) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

Number of papers			Degree			Betwenness			Eigenvector		
82	Abreu,P.	IST - UTL	117	Nave,M.F.F.	EURATOM IST - UTL	1310101	Pereira,L.	UNL	0,216	Nave,M.F.F.	EURATOM IST - UTL
79	Adam,W.	AAS	104	Varandas,C.A.F.	EURATOM IST - UTL	827257	Varandas,C.A.F.	EURATOM IST - UTL	0,165	Sartori,R.	EFDA CSU - Garching
59	Gulyurtlu,I.	INETI	97	Alves,E.	ITN	623518	Alves,E.	ITN	0,161	Borba,D.N.	EURATOM IST - UTL
53	Cabrita,I.	INETI	92	Sousa,J.B.	UP	618784	Silva,M.F.da	ITN	0,154	Lomas,P.J.	EURATOM UKAEA
49	Adye,T.	RAL	83	Soares,J.C.	UL	618273	Ramos,A.R.L.	ITN	0,152	Mantsinen,M.J.	EURATOM TEKES
45	Mendonca,J.T.	IST - UTL	82	Borba,D.N.	EURATOM IST - UTL	615217	Mendonca,J.T.	IST - UTL	0,142	Loarte,A.	EFDA CSU - Garching
45	Providencia,C.	UC	77	Manso,M.E.	EURATOM IST - UTL	590034	Teixeira,V.	UMi	0,141	Joffrin,E.	EURATOM CEA
45	Varandas,C.A.F.	EURATOM IST - UTL	77	Suttrop,W.	EURATOM IPP	569544	Sousa,J.B.	UP	0,139	Luna,E.dela	EURATOM CIEMAT
44	Freitas,M.C.	ITN	74	Goncalves,B.	EURATOM IST - UTL	510838	Soares,J.C.	UL	0,138	Suttrop,W.	EURATOM IPP
42	Providencia,J.da	UC	73	Mantsinen,M.J.	EURATOM TEKES	415760	Cardoso,S.	INESC-Lisboa	0,136	Goncalves,B.	EURATOM IST - UTL

Table 109: The authors with highest number of papers, degree, betweeness and eigenvector centralities (1995-2004)

D.11. - Year 2005

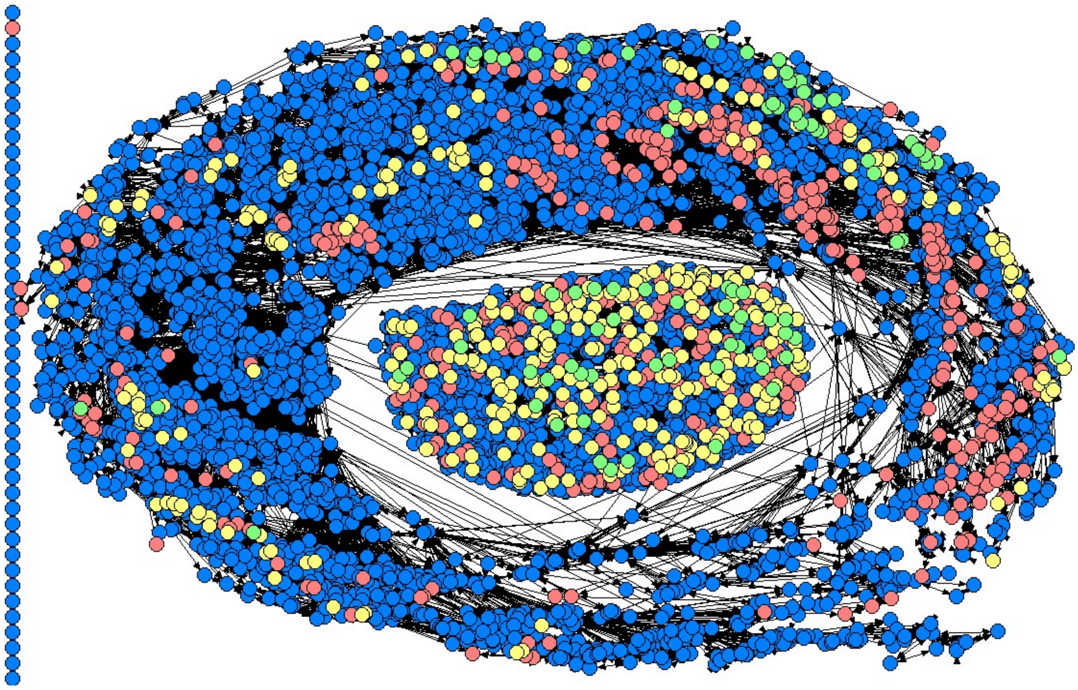


Figure 81: Energy field community co-authorship social network evolution (1995-2005) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

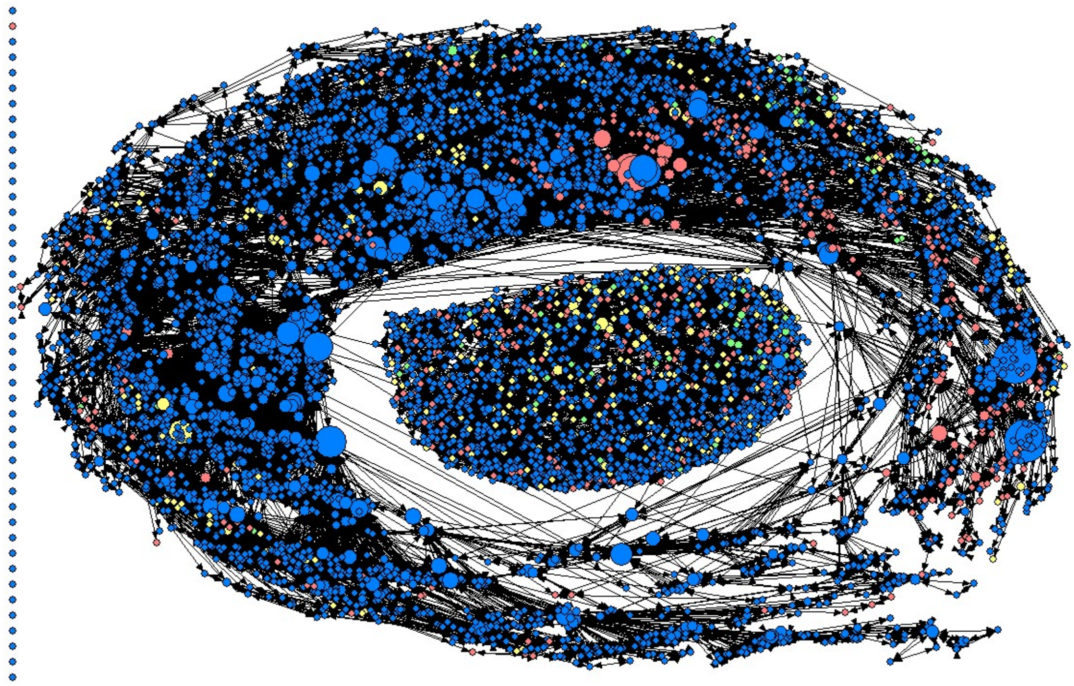


Figure 82: Number of Publications - Energy field community co-authorship social network evolution (1995-2005) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

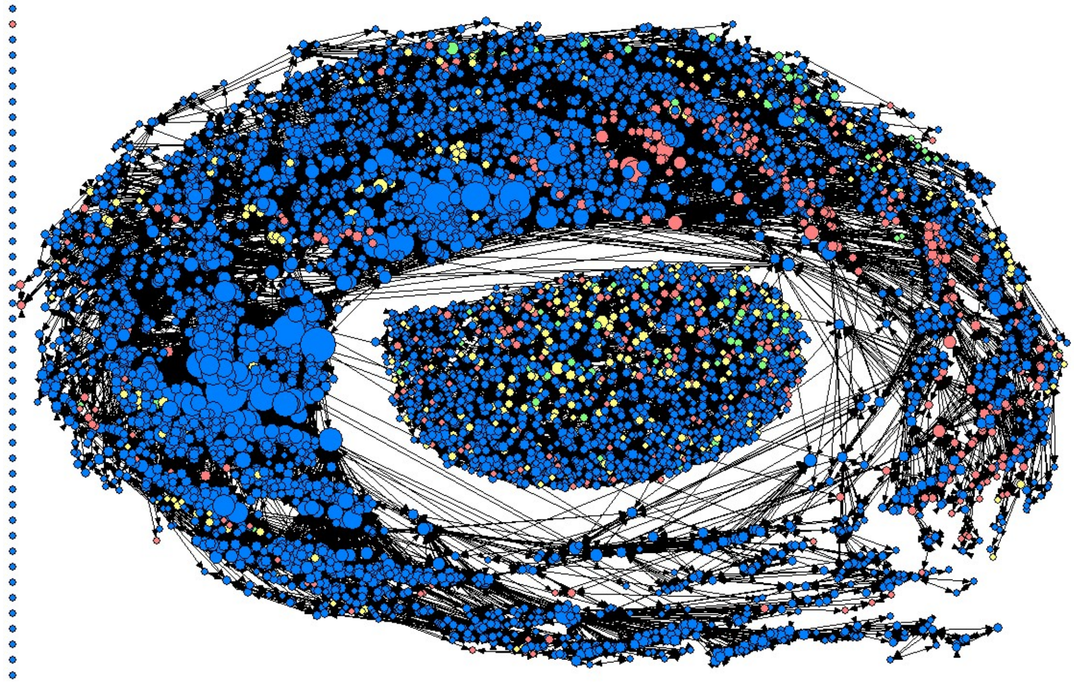


Figure 83: Degree Centrality - Energy field community co-authorship social network evolution (1995-2005) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

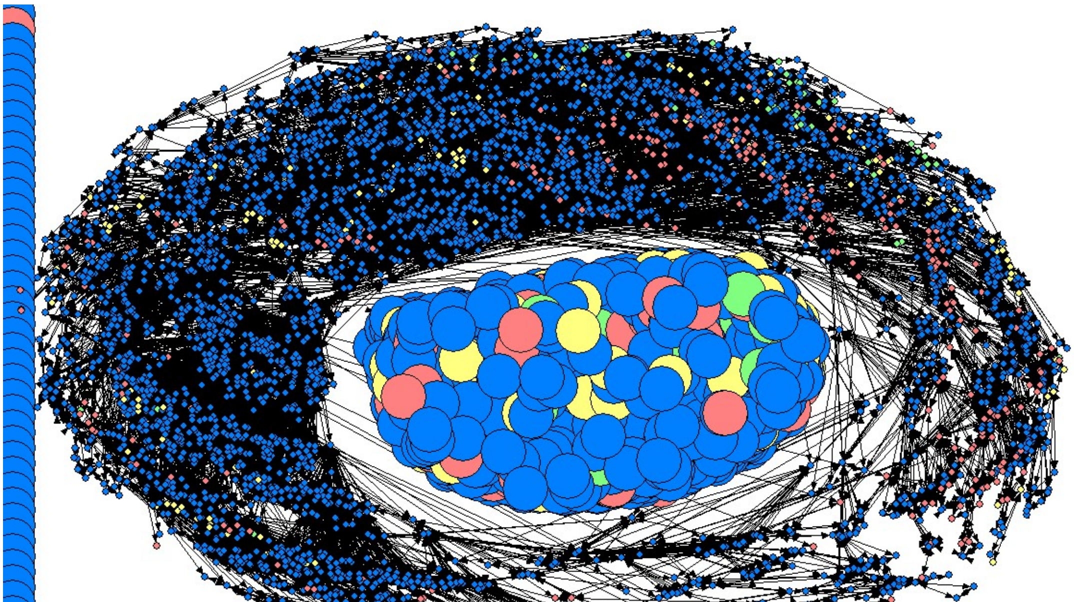


Figure 84: Closeness Centrality - Energy field community co-authorship social network evolution (1995-2005) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

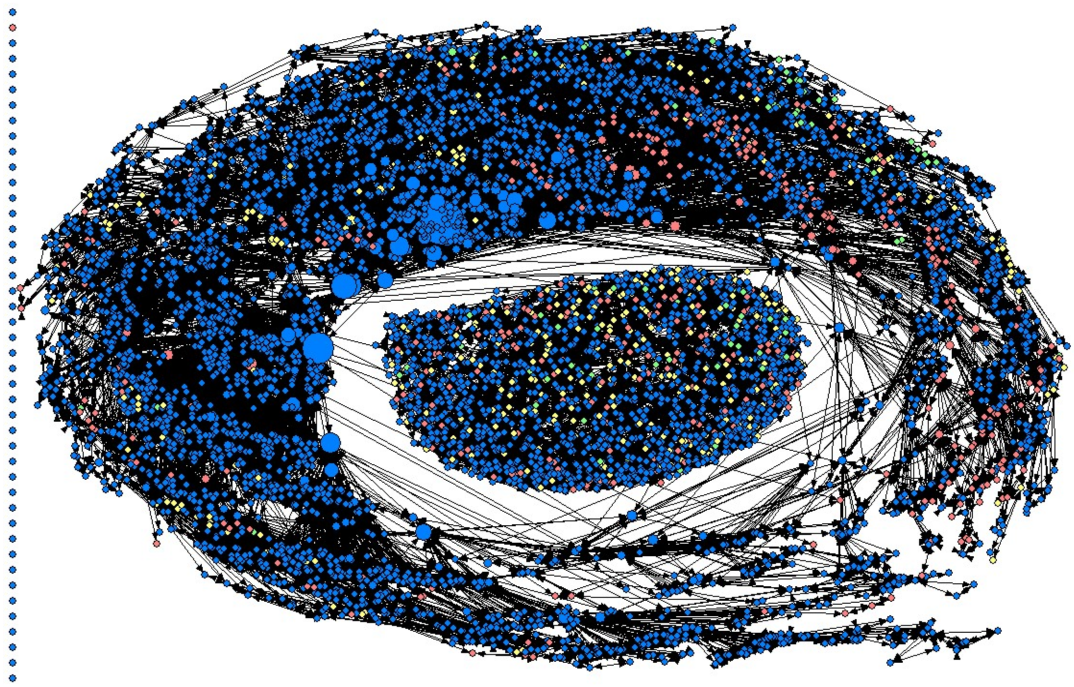


Figure 85: Betweeness Centrality - Energy field community co-authorship social network evolution (1995-2005) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

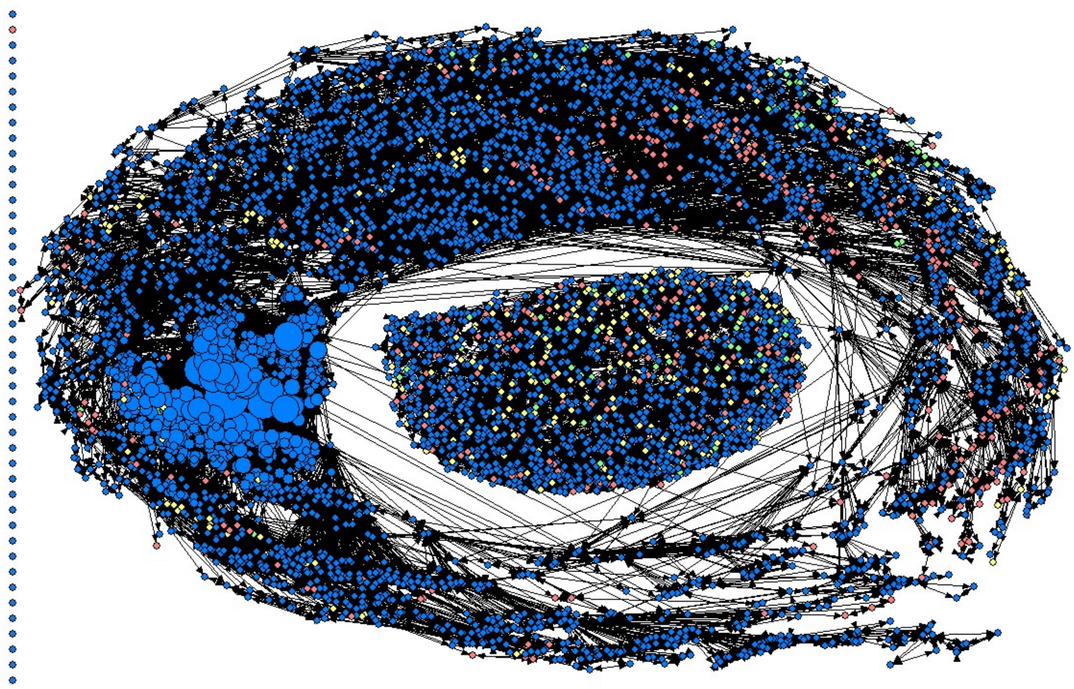


Figure 86: Eigenvector Centrality - Energy field community co-authorship social network evolution (1995-2005) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

Number of papers			Degree			Betwenness			Eigenvector		
90	Abreu,P.	IST - UTL	155	Alves,E.	ITN	2116251	Alves,E.	ITN	0,217	Nave,M.F.F.	EURATOM IST - UTL
87	Adam,W.	AAS	147	Nave,M.F.F.	EURATOM IST - UTL	1343021	Varandas,C.A.F.	EURATOM IST - UTL	0,168	Lomas,P.J.	EURATOM UKAEA
68	Gulyurtlu,I.	INETI	117	Varandas,C.A.F.	EURATOM IST - UTL	1008487	Pereira,L.	UNL	0,152	Borba,D.N.	EURATOM IST - UTL
60	Cabrita,I.	INETI	111	Silva,C.G.	EURATOM IST - UTL	952592	Kozachok,A.S.	IPP	0,147	Maraschek,M.	EURATOM IPP
57	Mendonca,J.T.	IST - UTL	102	Borba,D.N.	EURATOM IST - UTL	789742	Mendonca,J.T.	IST - UTL	0,143	Loarte,A.	EFDA CSU - Garching
54	Freitas,M.C.	ITN	100	Barradas,N.P	ITN	723173	Fortunato,ElviraM.C.	UNL	0,143	Conway,G.D.	EURATOM IPP
54	Providencia,C.	UC	99	Sousa,J.B.	UP	669604	Amaral,V.S.	UAv	0,138	Sartori,R.	EFDA CSU - Garching
53	Varandas,C.A.F.	EURATOM IST - UTL	93	Soares,J.C.	UL	515255	Sousa,J.B.	UP	0,136	Mantsinen,M.J.	EURATOM TEKES
49	Adye,T.	RAL	90	Fortunato,ElviraM.C.	UNL	500842	Barradas,N.P	ITN	0,134	Parail,V.V.	EURATOM UKAEA
49	Providencia,J.da	UC	86	Goncalves,B.	EURATOM IST - UTL	494068	Teixeira,V.	UMi	0,131	Silva,C.G.	EURATOM IST - UTL

Table 110: The authors with highest number of papers, degree, betweeness and eigenvector centralities (1995-2005)

D.12. - Year 2006

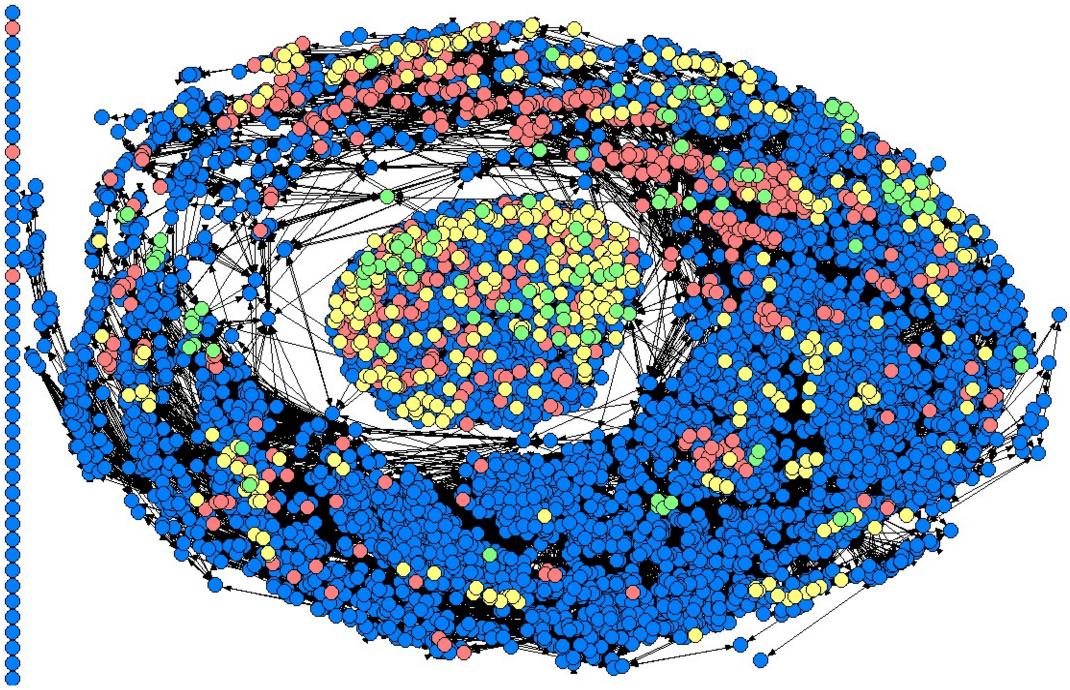


Figure 87: Energy field community co-authorship social network evolution (1995-2006) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

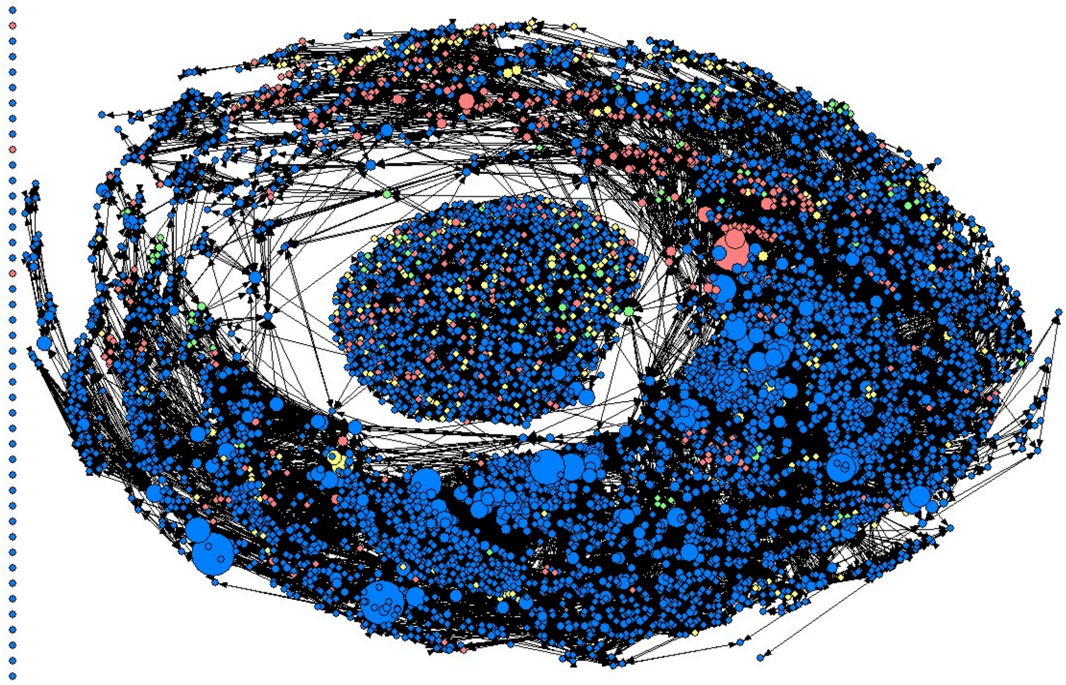


Figure 88: Number of Publications - Energy field community co-authorship social network evolution (1995-2006) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

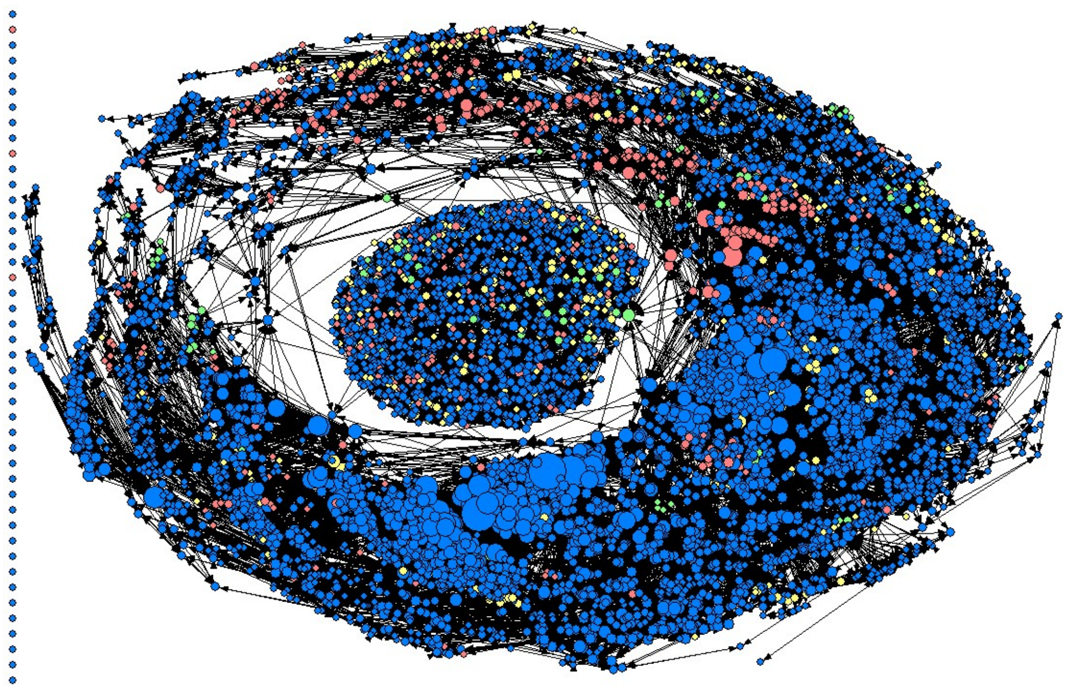


Figure 89: Degree Centrality - Energy field community co-authorship social network evolution (1995-2006) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

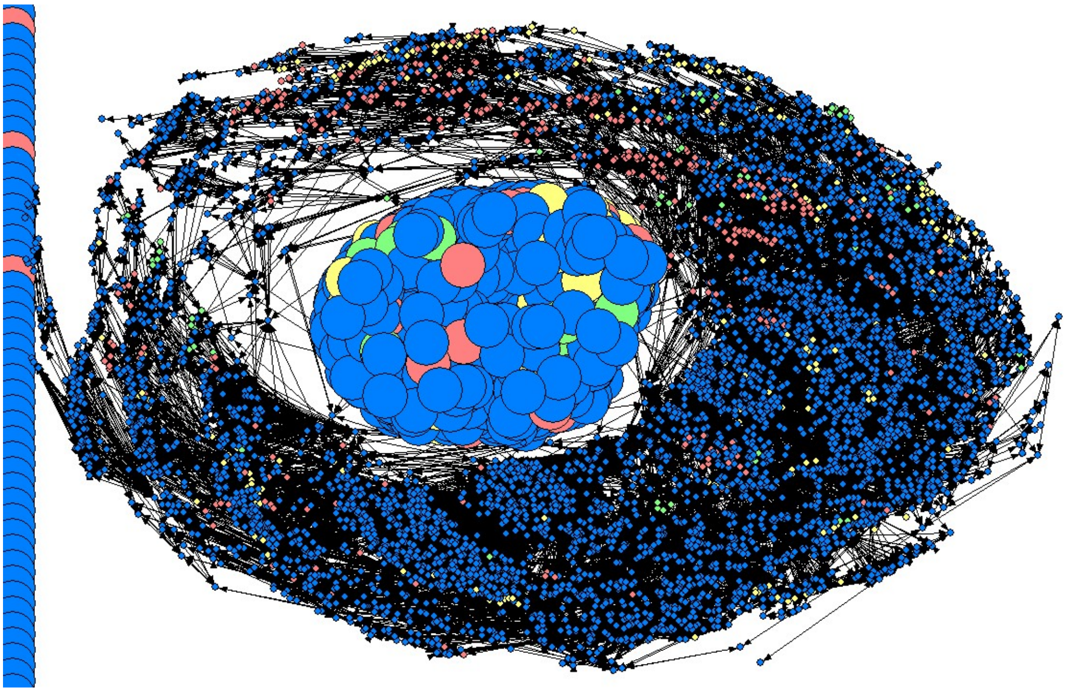


Figure 90: Closeness Centrality - Energy field community co-authorship social network evolution (1995-2006) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

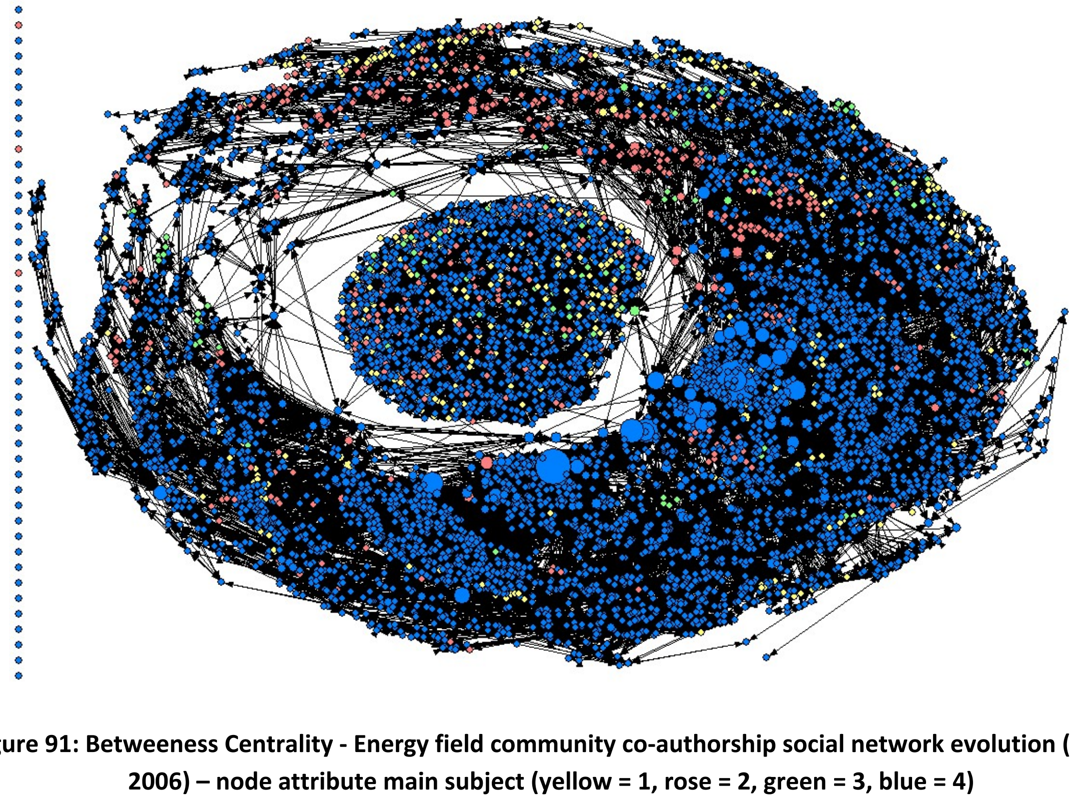


Figure 91: Betweeness Centrality - Energy field community co-authorship social network evolution (1995-2006) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

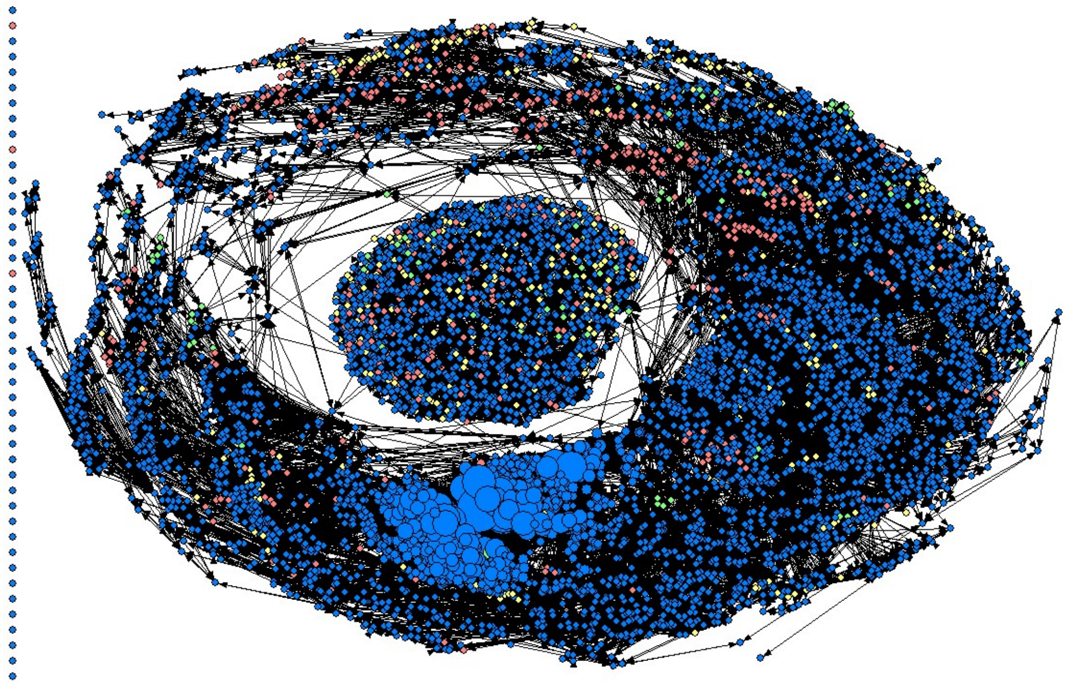


Figure 92: Eigenvector Centrality - Energy field community co-authorship social network evolution (1995-2006) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

Number of papers			Degree			Betwenness			Eigenvector		
101	Abreu,P.	IST - UTL	202	Alves,E.	ITN	2620214	Alves,E.	ITN	0,187	Nave,M.F.F.	EURATOM IST - UTL
98	Adam,W.	AAS	158	Varandas,C.A.F.	EURATOM IST - UTL	1922289	Varandas,C.A.F.	EURATOM IST - UTL	0,172	Borba,D.N.	EURATOM IST - UTL
79	Gulyurtlu,I.	INETI	148	Nave,M.F.F.	EURATOM IST - UTL	1155182	Pereira,L.	UNL	0,172	Lomas,P.J.	EURATOM UKAEA
77	Alves,E.	ITN	138	Barradas,N.P	ITN	1132128	Carvalho,P.	EURATOM IST - UTL	0,158	Luna,E.dela	EURATOM CIEMAT
75	Varandas,C.A.F.	EURATOM IST - UTL	136	Silva,C.G.	EURATOM IST - UTL	1092475	Barradas,N.P	ITN	0,158	Mantsinen,M.J.	EURATOM TEKES
68	Cabrita,I.	INETI	126	Borba,D.N.	EURATOM IST - UTL	1065083	Mendonca,J.T.	IST - UTL	0,140	Baar,M.de	EURATOM FOM
67	Providencia,C.	UC	107	Sousa,J.B.	UP	940075	Amaral,V.S.	UAv	0,134	Belo,P	EURATOM IST - UTL
65	Mendonca,J.T.	IST - UTL	104	Fortunato,ElviraM.C.	UNL	816487	Kozachok,A.S.	IPP	0,132	Joffrin,E.	EURATOM CEA
62	Freitas,M.C.	ITN	103	Conway,G.D.	EURATOM IPP	793913	Teixeira,V.	UMi	0,127	Alper,B.	EURATOM UKAEA
62	Providencia,J.da	UC	101	Mantsinen,M.J.	EURATOM TEKES	787641	Fortunato,ElviraM.C.	UNL	0,126	Sartori,R.	EFDA CSU - Garching

Table 111: The authors with highest number of papers, degree, betweeness and eigenvector centralities (1995-2006)

D.13. - Year 2007

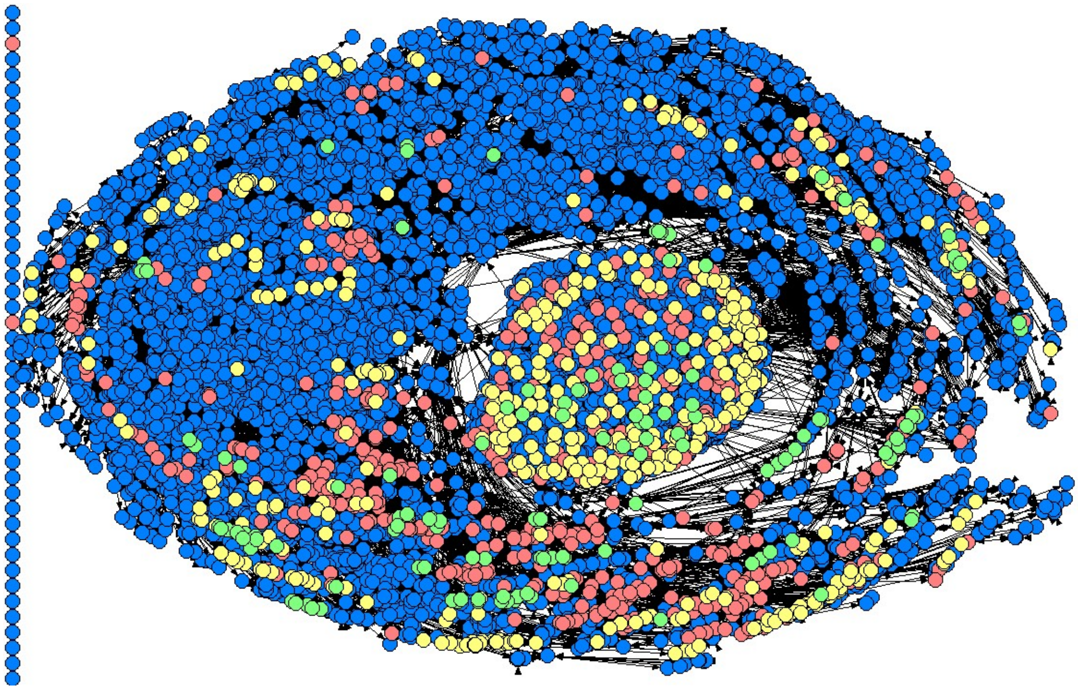


Figure 93: Energy field community co-authorship social network evolution (1995-2007) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

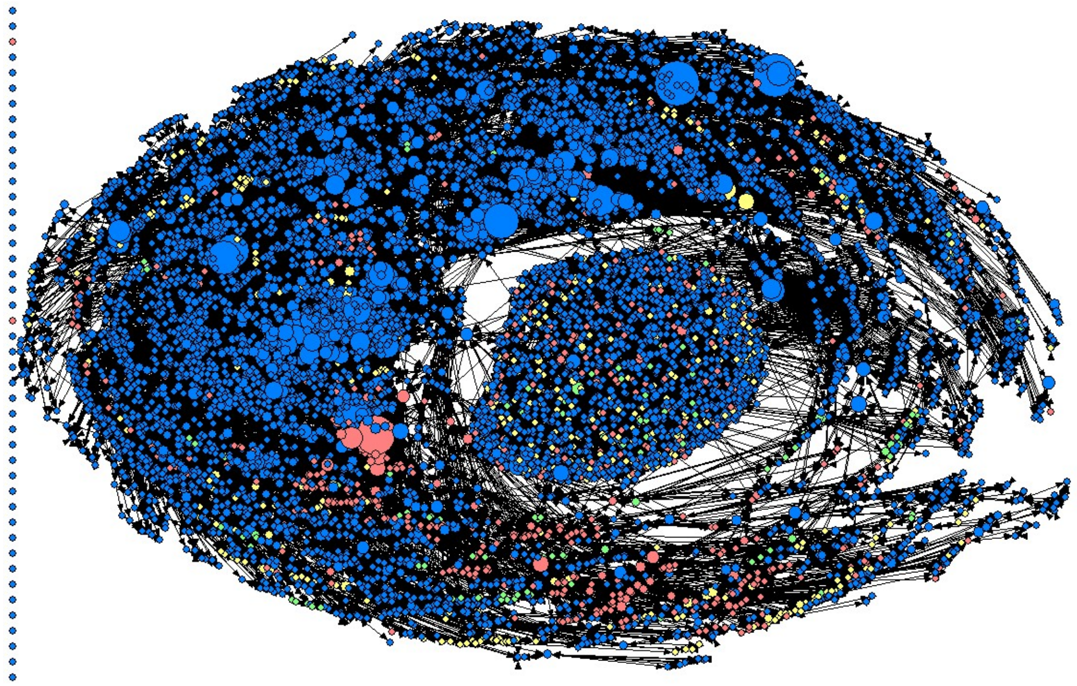


Figure 94: Number of Publications - Energy field community co-authorship social network evolution (1995-2007) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

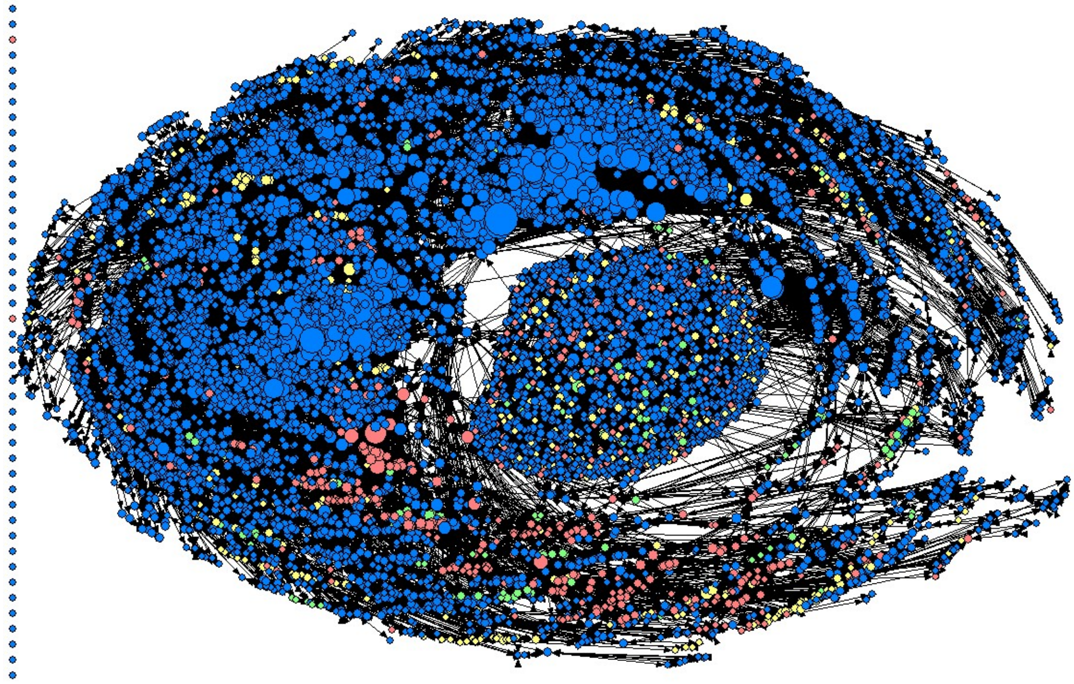


Figure 95: Degree Centrality - Energy field community co-authorship social network evolution (1995-2007) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

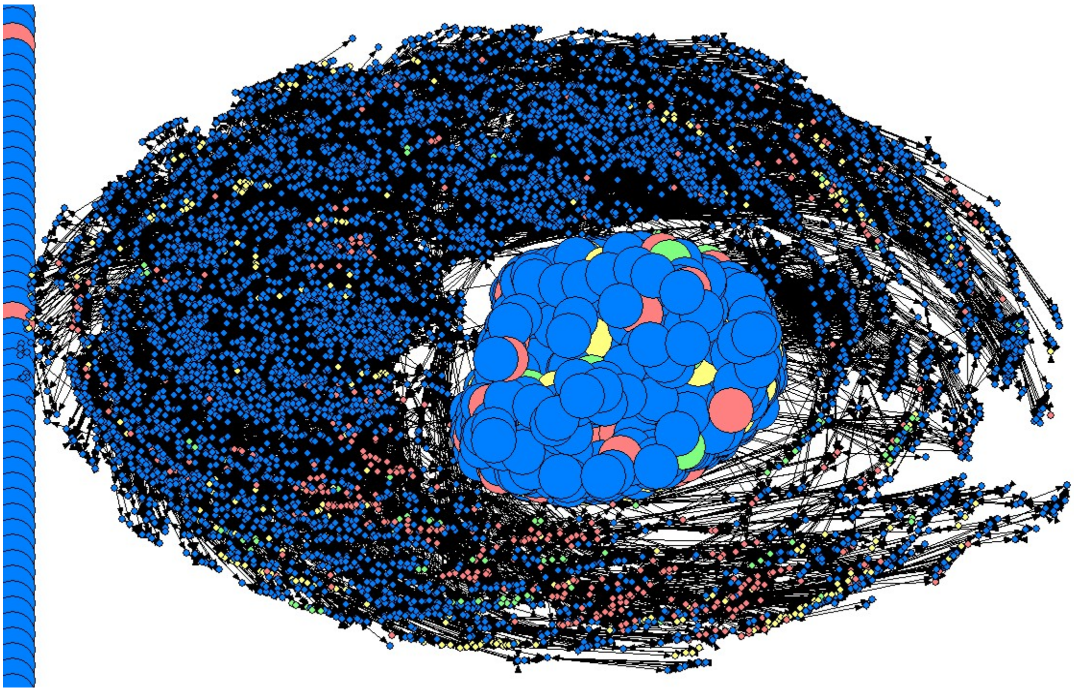


Figure 96: Closeness Centrality - Energy field community co-authorship social network evolution (1995-2007) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

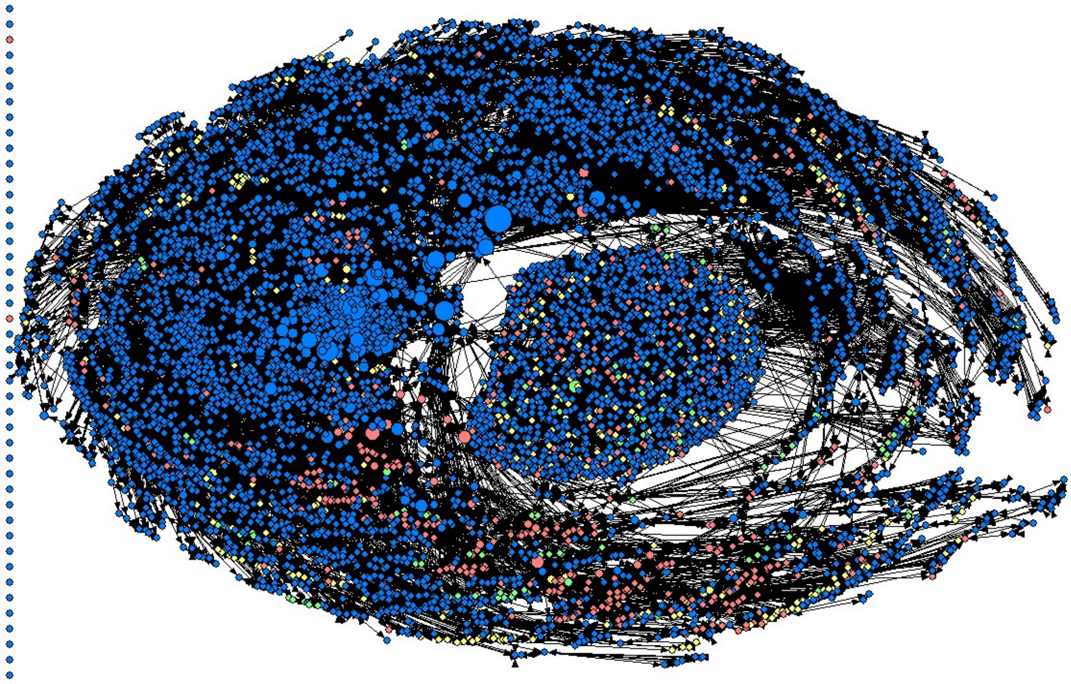


Figure 97: Betweeness Centrality - Energy field community co-authorship social network evolution (1995-2007) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

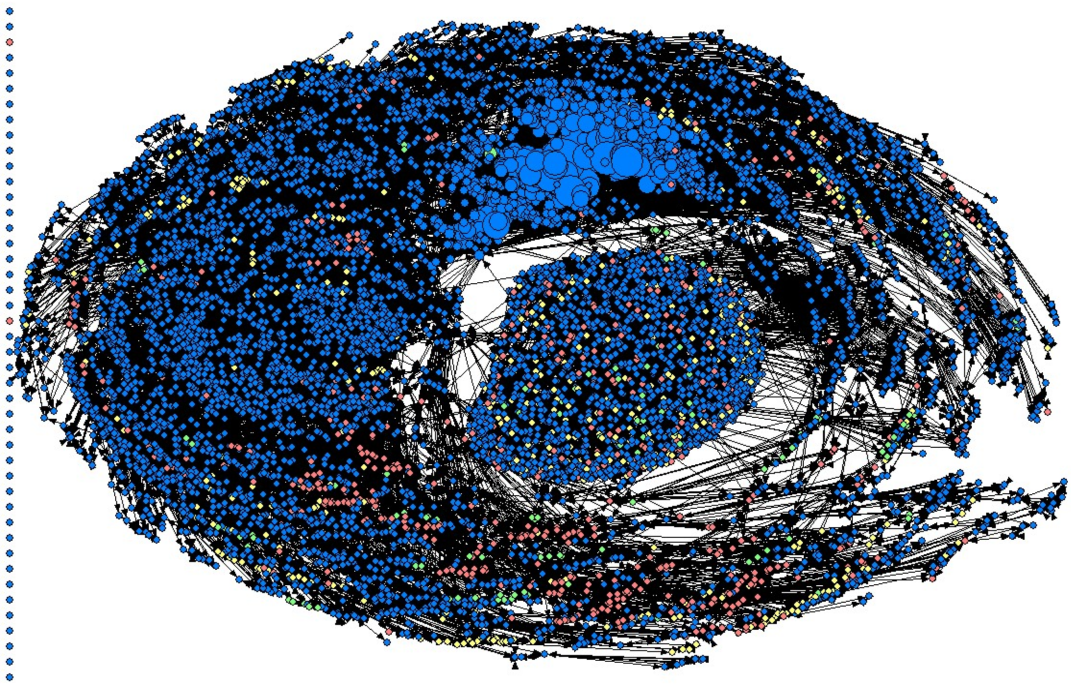


Figure 98: Eigenvector Centrality - Energy field community co-authorship social network evolution (1995-2007) – node attribute main subject (yellow = 1, rose = 2, green = 3, blue = 4)

Number of papers			Degree			Betwenness			Eigenvector		
106	Abreu,P.	IST - UTL	229	Alves,E.	ITN	3152510	Alves,E.	ITN	0,197	Nave,M.F.F.	EURATOM IST - UTL
103	Adam,W.	AAS	165	Nave,M.F.F.	EURATOM IST - UTL	1691909	Varandas,C.A.F.	EURATOM IST - UTL	0,168	Borba,D.N.	EURATOM IST - UTL
92	Alves,E.	ITN	160	Varandas,C.A.F.	EURATOM IST - UTL	1412103	Barradas,N.P	ITN	0,156	Luna,E.dela	EURATOM CIEMAT
91	Gulyurtlu,I.	INETI	156	Barradas,N.P	ITN	1217266	Amaral,V.S.	UAv	0,155	Lomas,P.J.	EURATOM UKAEA
82	Varandas,C.A.F.	EURATOM IST - UTL	150	Silva,C.G.	EURATOM IST - UTL	1127379	Carvalho,P.	EURATOM IST - UTL	0,154	Mantsinen,M.J.	EURATOM TEKES
78	Cabrita,I.	INETI	136	Borba,D.N.	EURATOM IST - UTL	1098431	Fortunato,ElviraM.C.	UNL	0,146	Kiptily,V.G.	EURATOM UKAEA
77	Providencia,C.	UC	116	Conway,G.D.	EURATOM IPP	1088652	Reis,M.A.	ITN	0,142	Alper,B.	EURATOM UKAEA
72	Providencia,J.da	UC	115	Fortunato,ElviraM.C.	UNL	1058830	Teixeira,V.	UMi	0,141	Sharapov,S.E.	EURATOM UKAEA
68	Mendonca,J.T.	IST - UTL	111	Sousa,J.B.	UP	933251	Pereira,L.	UNL	0,139	Baar,M.de	EURATOM FOM
67	Freitas,M.C.	ITN	110	Amaral,V.S.	UAv	863510	Vieira,J.	IST - UTL	0,134	Noterdaeme,J.M.	EURATOM IPP

Table 112: The authors with highest number of papers, degree, betweeness and eigenvector centralities (1995-2007)